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Variation Found in Potential Genes Influencing Growth and Carcass Composition in *Ovis aries*: UCP1 and PRKAG3.

A Dissertation

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of the requirements for the Degree of

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by

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Abstract

Economically important production traits in the New Zealand sheep meat industry underpin one of the country's most significant agricultural exports. Polymerase Chain Reaction-Single Strand Conformational Polymorphism (PCR-SSCP) was utilised to detect the variation within two genes in sheep which are hypothesised to have involvement in body growth and compositional traits in sheep (*Ovis aries).* Variation in the the gene encoding uncoupling protein 1 in both the promoter region and intron 5 region was found to be significantly influenced by congenital effects due to sire and relatedness of the 1125 individuals typed. This casts uncertainty upon previous results indicating that the gene is involved in the partitioning of energy consumed to the production of lean meat as opposed to adipose tissue. The PRKAG3 gene that has shown promising results in terms of skeletal glycogen content and lipogenesis in other species was found to vary significantly ($P<0.001$) between sheep breeds. No phenotypical information was analysed during this study and as such, further research is required to quantify any potential effects of both genes. As the New Zealand sheep meat industry faces many challenges in variability, any advantages that may be garnered from either UCP1 or PRKAG3 could have significant profitability advantages if they prove a valuable asset to breeding programmes.

Keywords: Sheep, UCP1, PRKAG3, Uncoupling Protein, AMPK, Composition, PCR-SSCP, Genetic Variation.

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Chapter 1

Introduction

New Zealand has long been known as a leading producer of agricultural products, and its place on the world stage of sheep meat is amongst the best due to the countries pastoral agriculture reputation. The profitability and level of production of sheep farms has altered over previous decades with many changes and challenges eventuating. Some of these adversities have been due to changes in financial stability through governmental reform, confinement to increasingly marginal land due to weakening competitiveness with other industries and changes in customer preferences in terms of the meat products produced. Conversely, developments within the sheep meat industry have been achieved in relation to technology development and sheep breeding which have increased both the quality and quantity of meat products produced.

Advances in sheep breeding have escalated proportionately with the increase in technology that assists farmers in identifying ewes and rams that have above flock average performance. The identification of correlations between DNA markers and these phenotypes in conjunction with individual DNA sequencing enables farmers to greatly improve production for many different traits. In relation to the economically important traits of growth rate and carcass composition, uncoupling protein 1 (UCP1) and protein kinase adenosine monophosphate-activated gamma 3 (PRKAG3) have been identified as genes potentially influencing these traits. Previous research has indicated that their potential may be influenced by breed and sire. As such, this report looks at the variation observed within these two genes to classify whether they hold potential for further research in the *Ovis aries* breed.

Chapter 2

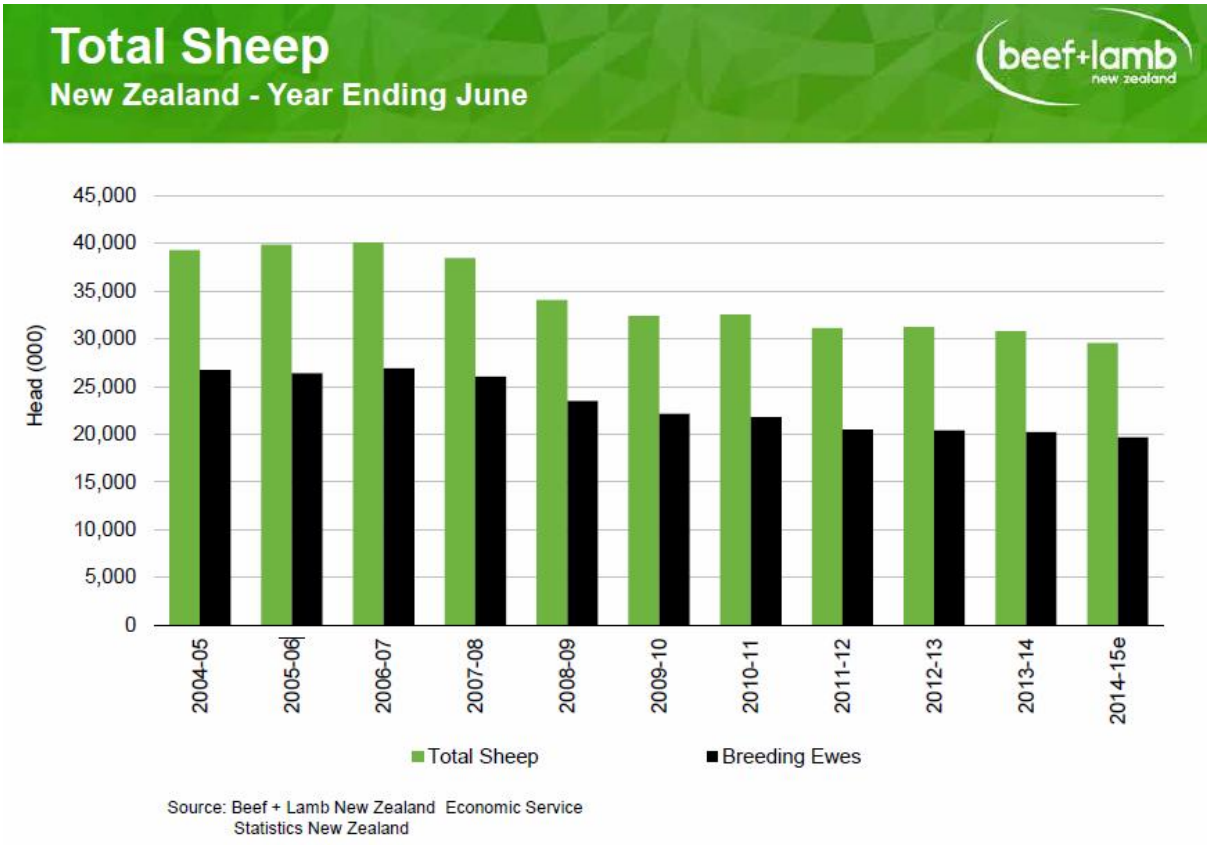
Literature Review

2.1 The New Zealand Sheep Meat Industry

2.1.1 Overview

Sheep farming has been one of the dominant agricultural sectors of New Zealand since the first sheep were imported midway through the 19th century (Stringleman and Peden, 2015). The advent of transport through railway and refrigerated shipping in the 1880's opened up what was to be one of New Zealand's largest exports and this began a country-wide expansion into sheep farming (MacLeod and Moller, 2006). This expansion took a sharp decline in the late 1980's following governmental reforms, low commodity prices and sequential droughts (MacLeod and Moller, 2006) and at present point, New Zealand sheep numbers sit in a relatively stable position at around 30 million, as can be seen in Figure 1 below. Romney sheep are the most predominant breed of sheep in New Zealand due to their hardiness and ability to perform in a range of environments and climates (Beef and Lamb NZ, 2015). New Zealand now exports around 90% of all agricultural products produced (Robertson, 2010) and although New Zealand's sheep population is low compared to other countries, New Zealand holds around a 40% share of the sheep meat export industry (Clemens and Babcock, 2004). The industry now annually contributes $2.8 billion to the New Zealand's export earnings (Bensemann and Shadbolt, 2015).

Figure 1; Sheep number trends over the past decade (Retrieved from; Beef and Lamb NZ, 2015)



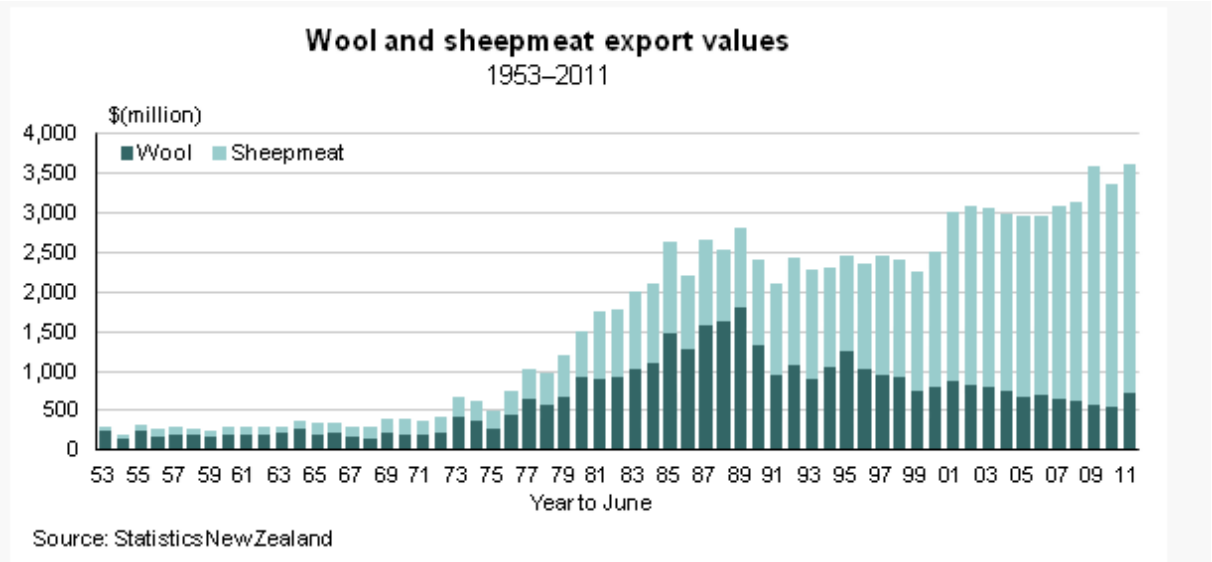
The importance of meat and protein based foods have become of greater consequence with increased knowledge in terms of nutrition and an increasing world population. This has led to an increase in demand for lamb products and New Zealand lamb products have become an international frontrunner of the industry (Clemens and Babcock, 2004). This partially stems from the country's ability to produce high-quality, niche products that are produced in a country that has been branded clean, green and disease-free (Clemens and Babcock, 2004; Bensemann and Shadbolt, 2015). However as there is only small opportunity for sale of sheep meat in the New Zealand domestic market, the New Zealand sheep industry is more vulnerable to changes in international market prices (Bensemann and Shadbolt, 2015).

2.1.2 Sheep Breeds

There are a range of sheep breeds that are used in pastoral sheep farming systems. This trial utilised the DNA from 16 different breeds that are common in New Zealand and Australia. The breeds utilised are a mixture of breeds that are dual purpose; producing both meat and wool, meat breeds or wool breeds. As previously mentioned, Romney are the most common breed of sheep in New Zealand due to its hardy characteristics and ability to produce both meat and wool. However, due to

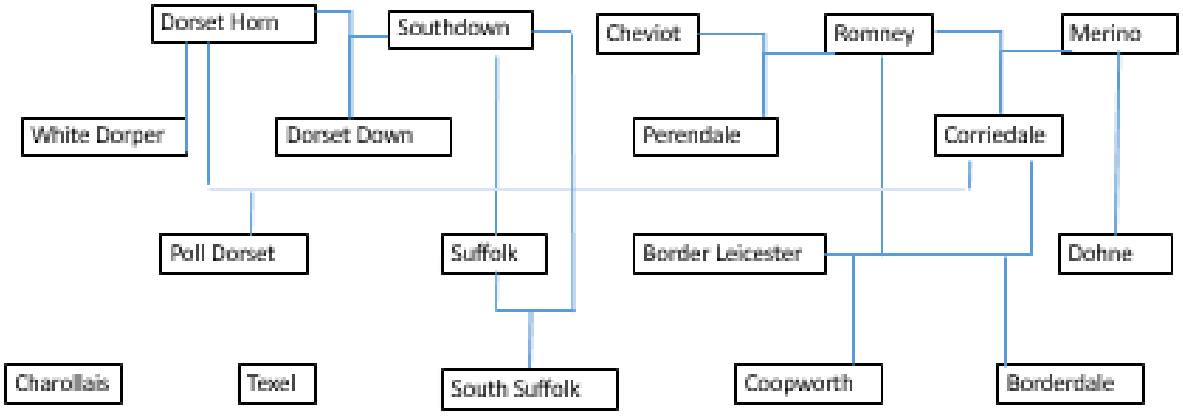
the range of climatic conditions in New Zealand and also as a result of changing market expectations and prices in both the red meat industry and the wool industry, a larger range of breeds are being utilised on New Zealand farms. Dual purpose breeds are still the predominant breeds in New Zealand, despite recent low prices in the wool market (Figure 2).

Figure 2; Changes in export earnings from wool and sheep meat (Statistics New Zealand, 2015)



Many of the breeds are also interrelated and are extensions of already established breeds as can be seen in Figure 3.

Figure 3; Development of New Zealand Sheep Breeds



Published studies have also reiterated the interrelationships between several sheep breeds such as Sise et al, (1991) who observed the variation among 10 loci between 5 different breeds of sheep. These results indicated that Romney, Coopworth and Perendales have similar variation at these loci and likewise, Merinos and Texels had similar variation. The relationship between Romney,

Coopworth and Perendale is expected to be similar as they are all descended directly from the Kent Romney. In addition to this, similar genetic distances could be expected between the Dorset breeds and Suffolk and Southdown breeds given that they are descended from the same gene pool. Kijas et al, (2009) concurred on the relatedness between sheep breeds as results from genome-wide SNP analysis showed overlapping genetic aspects and a low differentiation between breeds. This is due not only to the short evolutionary history of the domesticated sheep, but also to geographical aspects and the degree of interbreeding and diversification between breeds that has resulted.

2.1.3 Current Influential Issues in the New Zealand Sheep Industry

The intensification of New Zealand farming systems has played a part in meeting the demand for exports and to increase the profitability of sheep farming systems (Amer, 2014). Through advances in soil science, fertilisers and plant and animal breeding, it is estimated that around a 5% increase in productivity has been achieved within the period of 1961 and 2001 (MacLeod and Moller, 2006). On the other hand, New Zealand exports have increased transport costs associated with its exports, this also intensifies the need to gain top prices for lamb and mutton products. Alongside these challenges are practical issues that farmers face in conforming to the demands of a supply chain that is increasingly consumer-driven (Morris, 2009). Due to public perceptions regarding fat and its relation to diseases and health concerns such as obesity, cardiovascular disease, high cholesterol, blood pressure levels and diabetes, the supply chain of lamb meat is becoming more consumer driven towards lean cuts of meat with low fat quantity. Many higher income individuals and families are now not only seeking to buy lamb as a red meat product but are also looking to purchase a product that is healthy to consume, fresh, convenient to prepare and ethically produced. As these factors influence the market and the price that can be gained for lamb products, meat processors dictate their prices in relation to the quality of raw product that they receive. In New Zealand, lamb and mutton are classed upon the level of measurable fat on each carcass. The consumer desire for healthier meat products has meant that meat processors encourage farmers to produce lambs with a Y grade (lowest fat content) in order to gain the best prices for their products on the export market (Beef and Lamb New Zealand, 2012).

The industry faces other challenges in terms of sustainability as sheep are not the most efficient converters of feed to meat products (Morris, 2009). This, in part has led to conversion of many farms previously utilised as sheep properties to other agricultural enterprises such as dairy or intensive cropping. Dairy herd numbers in New Zealand have doubled in the period of 1990 and 2009 and this has been in part due to increased dairy commodity prices and irrigation of land that was once only suitable for dryland grazing and finishing of lambs (Robertson, 2010). Expansion of existing dairy

farms has also occurred with dairy farmers purchasing established sheep properties in order to achieve increases in profitability through economies of scale (Robertson, 2010). The lacklustre prices of sheep meat markets in conjunction with increased costs of production has assisted this move to other agricultural enterprises and as a result, sheep properties are increasingly confined to harder, steeper and more climatically challenging land (Amer, 2014).

In response to this, the approach to increasing production and profitability of these farming systems has generally focused on yielding more either through increasing stocking rates or through improved feeding that enables a higher rate of weight gain in lambs (McLeod and Moller, 2006). In terms of genetic advances made, a proportion of the increased productivity has been due to improvements in lambing rate of 1.7% per annum since 1991 (McLeod and Moller, 2006; Morris, 2009). Fecundity and reproductive traits, weight gain and the efficiency with which sheep utilise feed resources to accumulate tissue are traits that have also been a breeding focus for many farmers (Amer, 2014). In conjunction, many farmers and meat processors are now alternatively looking to improve profitability of the sheep meat industry through adding value to the product (Amer, 2014). Many of the breeding goals resulting from this new direction are aimed at creating a product that conforms more accurately to customer demands. A variety of methods have been utilised to achieve this, one of these being a diversification of sheep breed and genetic technologies.

How farmers achieve this while still maintaining high performance in other areas of lamb fattening, finishing and the sheep enterprise as a whole is a difficult problem to solve.

2.2 Sheep Growth Rate

The growth rate achieved in sale lambs each year is a factor which is critical to the profitability of farm systems. Faster lamb growth can result in several advantages; a sooner date for lamb slaughter (resulting in less feed required to maintain the lambs and potential premium prices), a greater weight realised at slaughter if lambs are kept on, increased dressing percentage at slaughter, increased feed conversion efficiency and feed available for other stock (Muir et al, 2003; Kerr, 2010). These aspects mean that a higher growth rate in lambs results in an overall increase in the production of saleable meat from pasture or feed eaten (Marquez et al, 2012). Many different practical approaches are taken to increase lamb growth rate both pre and post weaning with the aim of achieving these benefits, the simplest approach being increasing lamb feed intake above their maintenance requirements. Other approaches include; increasing pasture quality, decreasing stocking rate, increasing the feeding level of ewes both pre and post lambing, changes in animal health regimes and bringing forward lambing dates (Muir et al, 2003; Kerr, 2010).

The genetic aspects that underpin lamb growth have also been widely researched and in most cases it has been revealed that phenotypic selection based on increased growth rate have reported heritabilities ranging from 0.03 (Snowder and Van Vleck, 2003), 0.13 (Bisset et al, 2011) and 0.28 and 0.20 for 42 day weight and 100 day (weaning) weights respectively (Neser et al, 2001). Some of these estimates are low heritabilities, however selection based upon growth rate has been shown to be highly correlated with feed efficiency, another factor which also aids in increasing sheep farm profitability. The study carried out by Snowder and Van Vleck (2003) indicated that promising economic returns could be made with increases in average daily gain and also that the identification of genes that are pivotal to the trait could be used to identify fast growing lambs with greater precision and increase the heritability of the phenotype. Marquez et al, (2012) also published significant results that outlined the benefits of crossing dams with terminal sires such as Charollais, Texel and Suffolk. With the use of selection indices, the offspring of rams selected for high growth were compared to those sired by rams with a low growth index and the resulting data showed an increase of 5.1 g/d average growth rate and higher body weight at every age, across all breeds.

2.3 Carcass Composition

The partitioning of consumed metabolisable energy (ME) into fat and lean meat in livestock production systems is complicated and the ratio with which this occurs varies between species. As a food source, fat yields 38 kilojoules of energy per gram which, in comparison to protein, yielding 29 kJ/g makes fat a substrate of high energy density (Webster, 1980). The proportion of ME that is converted into lean meat has been reported to be a maximum of around 3% in sheep whereas the level of fat that may be deposited can be higher and also has a larger degree of variability at between 5-20% (Webster, 1980). Protein synthesis is a process that demands a large amount of energy (ME) and as such, the synthesis of lean meat is a less efficient process than the synthesis of adipose tissue. Despite this, and the implications such as that it is more efficient to grow fat lambs than grow lean lambs off more feed, much of this fat is unwanted by consumers and is routinely removed during carcass processing (McFarlane et al, 2009).

In cellular terms, fat deposition is dependent upon lipogenesis and lipolysis and the factors that surround these anabolic and catabolic processes. A steady state of adipose tissues only occurs when fatty acid synthesis, fatty acid intake from feed and lipid mobilisation from adipose storage are all in homeostasis. Studies have shown increases in lipolytic rates of adipose tissue in lambs that were increasing in weight between the age of 8 and 32 weeks (Pothoven et al, 1975). This indicates that as fat is not only deposited intramuscularly, but also intermuscularly and subcutaneously, it is impossible to remove all fat from lamb carcasses during processing. Research has been carried out

into methods that could be used to decrease fat deposition while increasing the apportioning of ME to lean meat (McFarlane et al, 2009). However it has been noted that a level of around 3 per cent of fat in lamb meat results in a desired level of tenderness and optimum taste (Webster, 1980). The removal of all fat from lamb meat results in a food product that is tough, dry and unappealing to consumers. Finding the balance to achieve a level of fat deposition that both conforms to market demand in terms of taste and health considerations is a problem that New Zealand farmers are faced with while also trying to sustain an efficient and profitable farming system.

2.4 UCP1

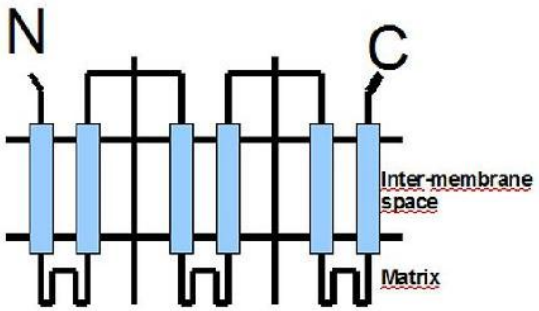
UCP1 is a gene that encodes a specific protein component in the inner membrane of brown adipose tissue (BAT) that enables non-shivering thermogenesis to occur. BAT is characteristically present in new-born mammals and is named as such for the high density of mitochondria within its cells. These mitochondria have a highly developed inner membrane and are the site of respiratory chain complexes and as such, BAT can oxidise substrates more effectively than white adipose tissue (Ricquier, 2011).

2.4.1 UCP1 Structure

The UCP1 gene which encodes the 32kd uncoupling protein, is located on chromosome 17 of *Ovis Aries* (GenBank, Gene ID : 494434) and is 6.7kb in size, including six exons and five introns. The coding sequence is 1621 base pairs in total (Yang et al, 2014).

As can be seen from Figure 4 below, the uncoupling protein UCP1 has a tripartite structure that is comprised of 3 repeated domains with 100 base pairs in each. The protein also has 3 polar loops that are extended out and 6 intramembrane domains in total.

Figure 4; structure of UCP1 protein. Retrieved from; http://parts.igem.org/Part:BBa_K141000



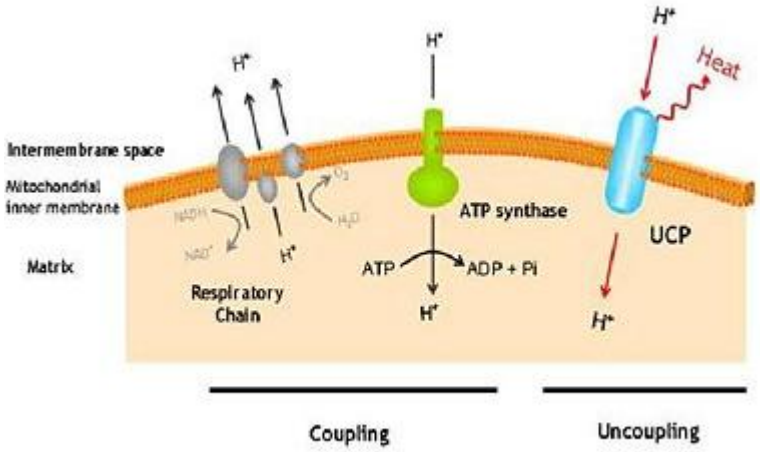
2.4.2 Previous Research

Uncoupling proteins have been the subject of extensive research over the past 60 years due to the role they play in uncoupling oxidative phosphorylation, thermogenesis and the maintenance of energy homeostasis. Under cold climatic conditions, non-shivering thermogenesis (NST) was observed in some new-born and hibernating mammals where body heat temperature increases to compensate for low temperatures. The biochemical factors that underpin this were later discovered and a 32kD protein isolated that was deemed responsible for the irregular proton conductances detected (Nicholls, 1976). The purification and sequencing of the gene was carried out in 1985 using cDNA, blot analysis and RFLP technology (Jacobsson et al, 1985; Aquila et al, 1985).

The mechanisms behind UCP1 were initially studied in mice and rat populations in the 1960's and it was established that brown adipose tissues (BAT) were host to higher levels of mitochondria than white adipose tissue (WAT) (Ricquier, 2011). The mitochondria of BAT were also observed to contain a highly developed inner membrane which is the site of respiratory chain complexes and this enables oxidation of substrates with greater efficiency (Ricquier, 2011). In studies involving non-shivering thermogenesis involving micro-calorimetric measurements of BAT, it was identified that a mitochondrial protein allowed energy to be produced as heat as opposed to producing ATP for use by the individual or for storage as fat (Bouillard et al, 1986). Figure 5 below provides a diagrammatic representation of how the uncoupling protein acts as a proton leak. This process leads to an increase in proton conductance of the mitochondrial membrane and heightened mitochondrial respiration. The proton electrochemical gradient is disintegrated as a result, leading to uncoupled respiration and the production of heat.

Figure 5; Uncoupling protein in inner mitochondrial membrane. Retrieved from; http://parts.igem.org/Part:BBa_K141000

The UCP1 protein allows protons to re-enter the mitochondrial matrix which thereby bypassing ATP synthase.



2.4.3 Activation of UCP1

The activation of UCP1 in response to cold stimuli was discovered to result from the release of norepinephrine by the sympathetic nervous system which rapidly activates lipolysis resulting in an increased level of free fatty acids (Nicholls and Rial, 1999). These free fatty acids act both as a substrate for oxidation and also activate UCP1. UCP1 uncouples respiration to ADP phosphorylation which results in the loss of protons as heat instead of ATP. The ability of this protein to uncouple oxidative phosphorylation has great potential in both humans and animals in relation to fat deposition and growth.

Results from research carried out with UCP1 in humans and mice have shown promising results indicating that the gene may have potential for application involving weight gain traits in other species, such as sheep. In knockout mice, the lack of the UCP1 gene resulted in heightened cold sensitivity due to impaired thermogenesis and greater risk of obesity (Bachmanov et al, 2001). As 79% of the UCP1 sequence was found to be homologous between human and rodents at nucleotide and amino acid level, it is suggested that a similar degree of conservedness may be observed between other mammalian species (Garruti and Ricquier, 1992). The coding sequence of Ovine UCP1 has an 81% similarity to rodents, 84 % similarity to humans and a high level of similarity (95%) to cattle (Yuan et al, 2012). As such, it has been suggested that UCP1 gene could be instrumental in live weight gain in lambs if this gene could be specifically bred for or as part of a selection criteria.

2.4.4 Potential Implications of UCP1 on Lamb Traits

The practical implications of UCP1 has been further researched since the protein and the underpinning genes have been discovered. The majority of the research carried out has been in mice and humans as a gene that can alter the deposition of adipose tissue and energy homeostasis has huge potential in the prevention of obesity and related diseases (Qi and Cho, 2008). As obesity and fat deposition are influenced by a number of factors, not the least of which being genetics, the understanding of genes that are potentially involved could be significant. Obesity in humans shows a large degree of heritability which indicates that thermoregulatory mechanisms may play a part in the storage of adipose tissue and the rate of weight gain (Jia et al, 2010). In some studies (Virtanen et al, 2009), UCP1 has been found to be active in white adipose tissue (WAT) in adult mice and humans suggesting that mitochondrial uncoupling may occur later in life than previously thought. Polymorphisms have been identified in the UCP1 gene, particularly in the promoter region as well as in exon 2 and exon 5, that are associated with traits such as the accumulation of body fat, gain of body weight and body mass index (BMI) (Jia et al, 2010). In humans, variation was discovered in the promoter region of the gene. As the promoter region can play an instrumental role in the expression of the gene at mRNA level, this could significantly the function of UCP1.

This could signify that other mammalian species may also possess such a mechanism that may be useful in productive terms in domestic livestock or in improving energy efficiency. In conjunction with the market pressures that the sheep meat industry currently faces in terms of profitability, the ability to recognise sheep that are good converters of feed to product, without gaining extravagant proportions of fat could be very beneficial. In sheep, the UCP1 gene holds great prospect in terms of decreasing fat deposition in lambs and/or increasing both deposition of lean tissue and the growth rate of lambs. Yuan et al, (2012) investigated several sheep breeds and looked at the mRNA expression in lambs of ages between 2 and 12 months of age. During this study, it was found that although UCP1 expression did gradually decline from the 2 month mark onwards, it also increased in yearling lambs. As it was previously thought that UCP1 was only present in BAT and was predominantly lost in the post-natal period of growth this result indicates that UCP1 may have applications in terms of adult mammals also.

2.5 PRKAG3

2.5.1 PRKAG3 Structure

In sheep, the gene was identified as having 11 exons although the variation present in the gene is as yet unclear (Yang et al, 2015). The structure of the PRKAG3 gene is shown in Figure 6 (NCBI accession

number FJ685774). It is located on chromosome 2 in sheep and is known to be comprised of 1572 base pairs. A level of intermediate diversity was detected in a recent study by Yang et al, (2015) where 3 single nucleotide polymorphisms (SNPs) were identified. This insinuates that the gene is naturally polymorphic in sheep breeds.

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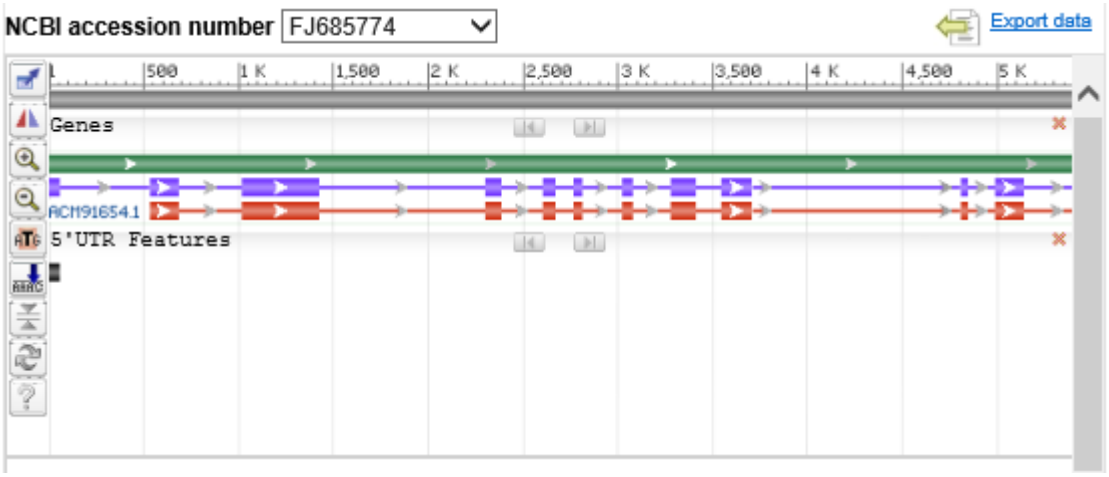

Figure 6; Ovine PRKAG3 Gene

2.5.2 Previous Research

The gene PRKAG3, short for protein kinase adenosine monophosphate-activated gamma 3 and its potential role in growth rate and meat quality has been thoroughly studied (Yang et al, 2015; Li et al, 2012; Mihaylova and Shaw, 2012). PRKAG3 has been shown to encode a γ, non-catalytic subunit of 5' AMP activated protein kinase (AMPK). AMPK is a heterotrimeric enzyme comprised of α, β and γ subunits that are involved in the regulation of cellular energy homeostasis. The activation of AMPK occurs as a result of cellular stresses that deplete ATP reserves within the body (Kahn et al, 2005) and also plays a role in the catabolic pathway that is responsible for the change to aerobic metabolism when sustained exercise is being carried out (Li et al, 2012). A low supply of ATP levels stimulate AMPK to increase the oxidation of fatty acids and promotes glucose ingesYtion for the production of energy (Mihaylova an-d Shaw, 2012) and also impedes processes that consume energy such as lipid, protein and carbohydrate biosynthesis (Kahn et al, 2005). In this way, AMPk plays a pivotal role in the control of energy homeostasis and as can be seen in Figure 7, can have significant effects on the synthesis, uptake and oxidation of biologically important components such as fatty acids, cholesterol, glucose and insulin.

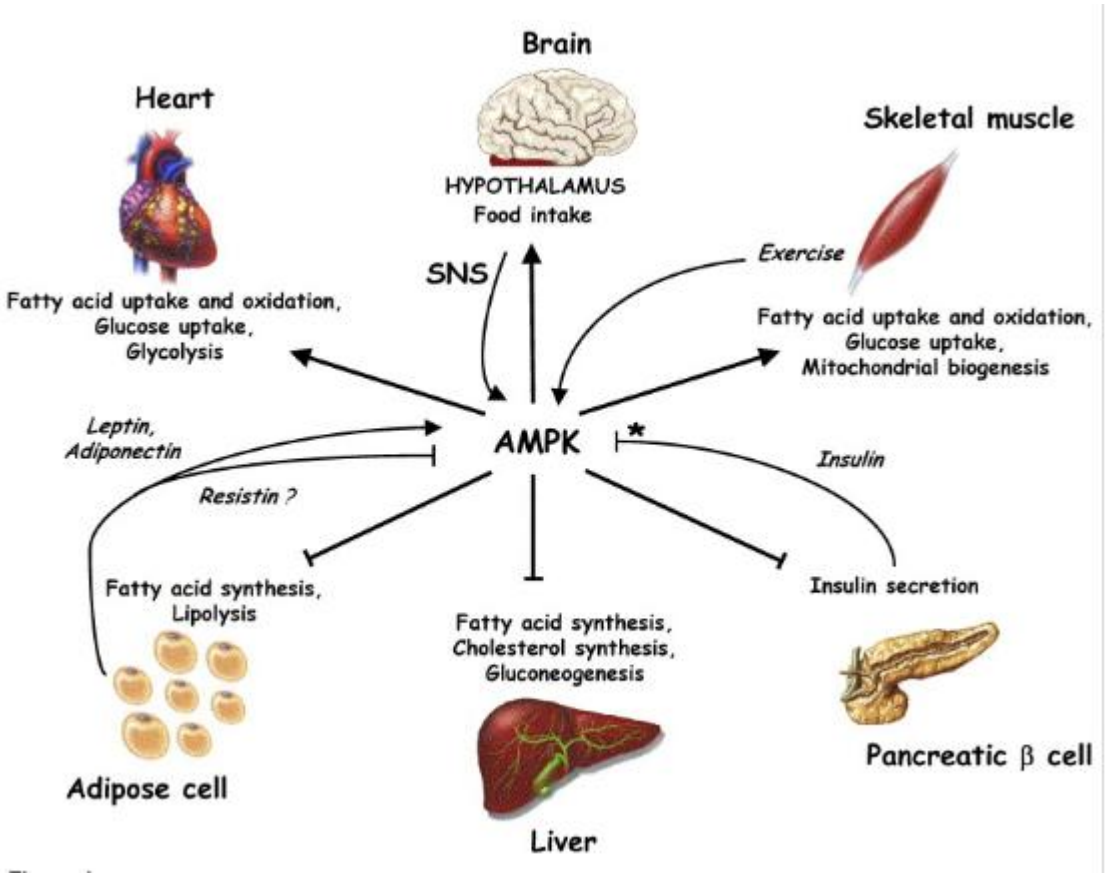

Figure 7; Role of AMPK within Mammals (Kahn et al, 2005)

AMPK, the PRKAG3 gene and their influence on phenotype has been studied in many different species including, mice, humans, cattle, pigs and sheep. Mice, in which the PRKAG3 gene was removed, showed an impaired level of lipid and glucose metabolism (Barnes et al, 2005). In humans, the gene displayed effects of impaired fatty acid oxidation and uptake of glucose (Weyrich et al, 2007). Some of the most extensive research into the PRKAG3 gene has been in pigs, where glucose metabolism and the storage of glycogen were affected by the PRKAG3 gene (Milan et al, 2000). Amarger et al, (2003) also observed abnormally high levels of glycogen in pig skeletal muscle due to a missense mutation in the PRKAG3 gene and additionally found a 72% similarity between the PRKAG3 sequence in pigs and in humans. Also in pigs, variation within the promoter sequence has been found to be involved in the expression of PRKAG3 (Ryan et al, 2012). Evidence suggests that these mutational changes are partly responsible for meat quality factors such as; pH, colour, water-holding capacity and tenderness (Johnson et al, 20015). Similar observations were also observed when the gene was studied in cattle as a mutational change from Argenine to Glutamine at the 200 position that showed phenotypic effects including increased muscle glycogen, decreased protein levels in meat and decreased meat pH was detected (Yang et al, 2015). These altered processes have

been shown to affect a multitude of phenotypes, the most significant of which being intramuscular fat deposition (Li et al, 2012) and meat quality factors (Yang et al, 2015).

2.5.3 Potential of PRKAG3 Gene in Lamb Traits

With the alteration of AMPK activity, the ability of an organism to uptake glucose from diet and the oxidation of fatty acids increases. As AMPK regulates the intake of energy of an animal, and is instrumental in the glucose and lipid uptake, usage and storage of organs such as the liver, heart, skeletal muscle and pancreas, its function is closely involved with obesity issues. If variation in the PRKAG3 gene that encodes the Y subunit of AMPK does influence the regulation and function of AMPK as research suggests, then it could be significant in lamb breeding programs where focus upon lean meat lamb growth exists.

Ryan et al, (2012) observed differences in the variation of PRKAG3 gene between pig breeds, primarily in the promoter region. In conjunction with differing phenotypic results between breeds signifies that the breed within a species may play a role in the expression of PRKAG3 and the degree of conservedness of the region between species suggests that this may also be true for sheep breeds.

Chapter 3

Methods

3.1 UCP1

3.1.1 Blood Samples

Blood samples of 1125 Romney sheep were utilised through the Lincoln University genotyping lab that were collected on FTA cards from the offspring of 18 different New Zealand rams.

3.1.2 Primer Sequences

Two PCR primers were utilised for the UCP1 gene as can be seen in Table 1 below. The primers were synthesised by Integrated DNA Technologies (Coralville, IA, USA).

Table 1; UCP1 Primer Sequences

Primer	Primer Sequence (5' – 3')
UCP1 – Y	F: AGATACAAGCGGAAGAGACAC
	R: TGAAGGGTTGGGTCTGTCA
UCP1 – Intron 5	F: CACTGGAGATGCGTGGCACAG
	R: GAAGCACACAAACATGATGATG

3.1.3 PCR – SSCP

PCR amplification was performed in a 15-µL reaction containing the genomic DNA on one 1.2-mm punch of FTA card, 0.25 µM of each primer, 150 µM dNTP's (Bioline, London, UK), 2.5 mM of Mg2+, 0.5 U of Taq DNA polymerase (Qiagen, Hilden, Germany) and 1× the reaction buffer supplied with the enzyme. The thermal profile consisted of 2 min at 94 ˚C, followed by 35 cycles of 30 s at 94 ˚C, 30 s at an annealing temperature of 62 ˚C and 30 s at 72 ˚C, with a final extension of 5 min at 72 ˚C. Amplification was carried out in S1000 thermal cyclers (Bio-Rad, Hercules, CA, USA). Primer UCP1-Y had an amplified size of 351 base pairs, and UCP1- intron 5 had an amplified size of 298 base pairs.

Amplicons were visualized by electrophoresis in 1% agarose (Quantum Scientific, Queensland, Australia) gels, using 1 x TBE buffer (89 mM Tris, 89 mM boric acid, 2 mM Na2EDTA) containing 200 ng/mL of ethidium bromide.

A 0.7-µL aliquot of each amplicon was mixed with 7 µL of loading dye (98% formamide, 10 mM EDTA, 0.025% bromophenol blue, 0.025% xylene-cyanol). After denaturation at 95 ˚C for 5 minutes, samples were rapidly cooled on wet ice and then loaded on 16 cm × 18 cm, 14% and 12% acrylamide: bisacrylamide (37.5:1) (Bio-Rad) gels (UCP1-Y and UCP1-intron 5 respectively). Electrophoresis of the samples with UCP1-Y primers were performed using Protean II xi cells (Bio-Rad), at 230 V for 18 h at 23.7 ˚C in 0.5 × TBE buffer. Electrophoresis of the samples with UCP1-intron 5 primers were performed using Protean II xi cells (Bio-Rad), at 300 V for 18 h at 12 ˚C in 0.5 × TBE buffer. All gels were silver-stained according to the method of Byun *et al.* (2009).

3.2 PRKAG3

3.2.1 Blood Samples

Through the Lincoln University genotyping lab, blood samples were received from 16 different breeds of sheep, the number of samples of each varying between 5 and 15, with 179 samples in total. The blood samples were collected from different farms in New Zealand and Australia onto FTA cards using the method outlined by Zhou et al, (2006).

3.2.2 Primer Sequences

For the PRKAG3 gene, two PCR primers, 3'-CTTCAGACACTATCAGTC-5' and 3'-CTAGATGGAAGTTCCGACGA -5', were designed based on the published sequences JX290313-JX290317 (Yan *et al*., 2012; Appendices A and B) to amplify a variable region of ovine *FABP4* containing part of exon 2 and intron 2. The primers were synthesised by Integrated DNA Technologies (Coralville, IA, USA).

3.2.3 PCR – SSCP

PCR amplification was performed in a 15-µL reaction containing the genomic DNA on one 1.2-mm punch of FTA card, 0.25 µM of each primer, 150 µM dNTP's (Bioline, London, UK), 2.5 mM of Mg2+, 0.5 U of Taq DNA polymerase (Qiagen, Hilden, Germany) and 1× the reaction buffer supplied with the enzyme. The thermal profile consisted of 2 min at 94 ˚C, followed by 35 cycles of 30 s at 94 ˚C, 30 s at an annealing temperature of 60 ˚C and 30 s at 72 ˚C, with a final extension of 5 min at 72 ˚C. Amplification was carried out in S1000 thermal cyclers (Bio-Rad, Hercules, CA, USA).

Amplicons were visualized by electrophoresis in 1% agarose (Quantum Scientific, Queensland, Australia) gels, using 1 x TBE buffer (89 mM Tris, 89 mM boric acid, 2 mM Na2EDTA) containing 200 ng/mL of ethidium bromide.

A 0.7-µL aliquot of each amplicon was mixed with 7 µL of loading dye (98% formamide, 10 mM EDTA, 0.025% bromophenol blue, 0.025% xylene-cyanol). After denaturation at 95 ˚C for 5 minutes, samples were rapidly cooled on wet ice and then loaded on 16 cm × 18 cm, 12% acrylamide: bisacrylamide (37.5:1) (Bio-Rad) gels. Electrophoresis was performed using Protean II xi cells (Bio-Rad), at 250 V for 18 h at 28 ˚C in 0.5 × TBE buffer. Gels were silver-stained according to the method of Byun *et al.* (2009).

3.3 Statistical Analysis

The genotyping of 1125 Romney blood samples and the 179 blood samples of varying breeds for the UCP1 gene and the PRKAG3 gene respectively were analysed using Minitab (Minitab 17.2.1, 2015). The variance of allele combinations produced for each gene were analysed (ANOVA) in order to identify any significant relationships between sires (UCP1) and between breeds (PRKAG3).

Chapter 4

Results

4.1 UCP1 Y Gene

Three variants of UCP1-Y were identified in Romney sheep, these being A, B and C. These contribute to six different combinations of genotype, specifically; AA, AB, AC, BB, BC and CC. The visual appearance of these genotypes following PCR-SCCP methods are shown in Figure 8.

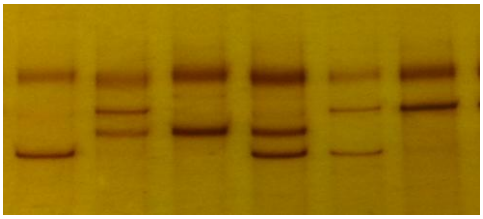

Figure 8; Variations of UCP1-Y

The genotypes which are most common within the sheep analysed are AA and AC and those that are least frequent are BB and CC (see Figure 9). Allele frequencies can be seen in Appendix A.1. 1

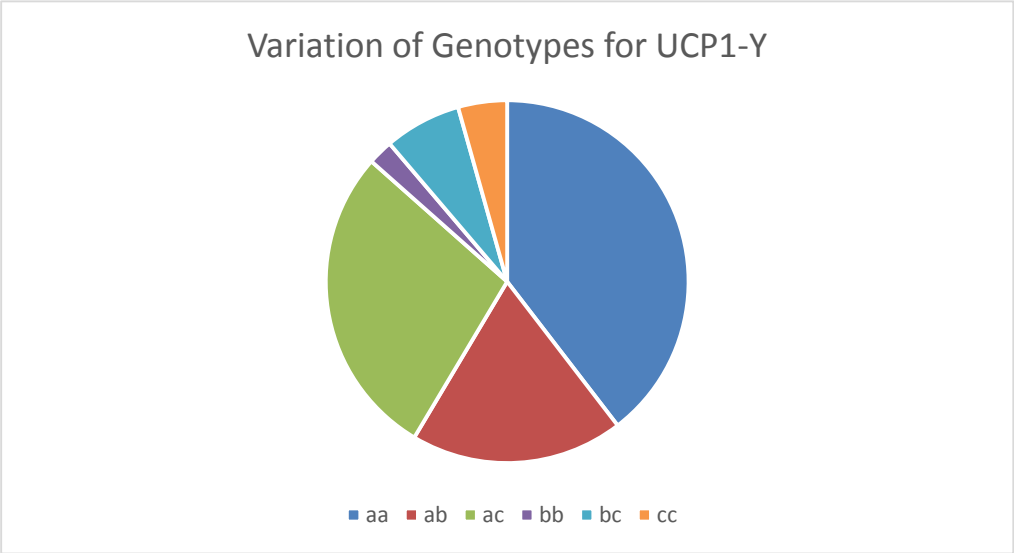

Figure 9; Genotypic Variation of UCP1 Y in Romney Sheep

4.1.1 Relationships between UCP1 Y and Sire

The relationship between UCP1 Y and the sire of individuals was analysed and indicated a significant result ($P < 0.005$) with an R^2 value indicating that 19.85% of the variation observed between groups is due to sire.

Table 2; ANOVA Output of UCP1 Y and Sire

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Ram ID	16	439.9	27.494	16.95	0.000
Error	1095	1776.7	1.623		
Total	1111	2216.6			

With genotypes numerically scaled, the mean of individual's genotype can be calculated. Figure 10 shows the distribution of these means and the degree with which variations occur for each group of individuals is also displayed (average standard deviation of 1.27).

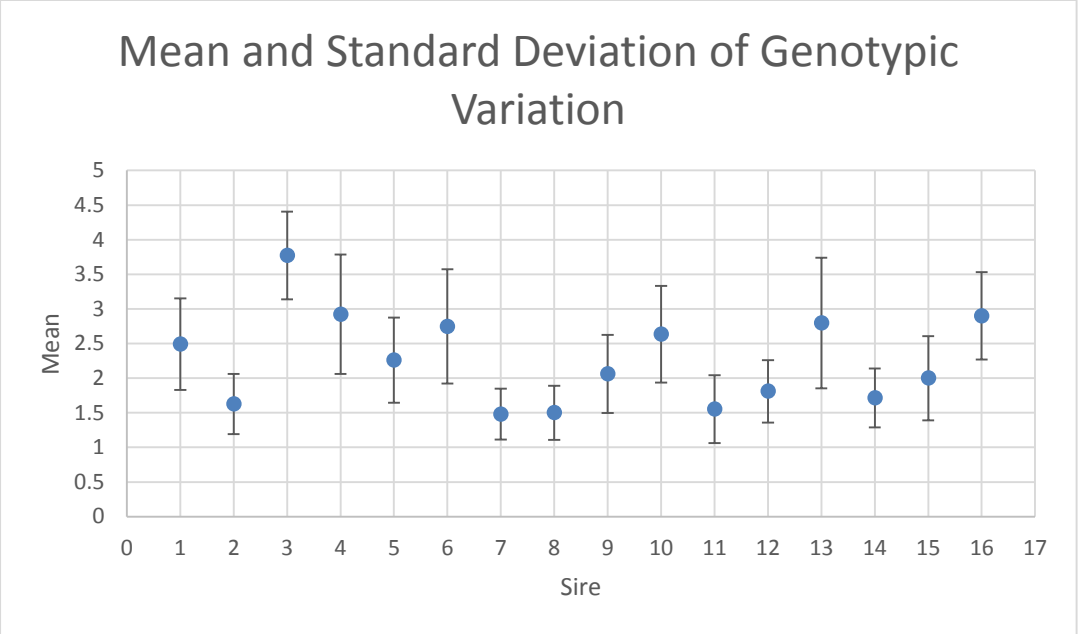

Figure 10; Means and Standard Deviations of UCP1 - Y Gene between Sires

Note; Means and Standard Deviations of each sire are determined from numeric scaling of each genotype as follows;

- aa = 1
- ab = 2
- ac = 3
- bb = 4
- bc = 5
- cc = 6

4.1.2 Relationship between UCP1 Y and Sex

The expression of UCP1 Y genotypes and the sex of individuals was also examined with no significant results produced (Table 3) and little difference between the means of sexes (Table 4).

Table 3; ANOVA Output of UCP1 Y vs. Sex

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sex	1	1.61	1.605	0.80	0.370
Error	1113	2220.16	1.995		
Total	1114	2221.76			

Table 4; Means Relationship between UCP1 - Y and Sex

Sex	N	Mean	Standard Deviation
Ewe	550	2.2745	1.4023
Ram	565	2.3504	1.4221

4.2 UCP1 Intron 5 Gene

Three variants of UCP1 Intron 5 were also identified as with UCP1 Y which also resulted in six combinations; AA, AB, AC, BB, BC and CC, four of which are shown in Figure 11.

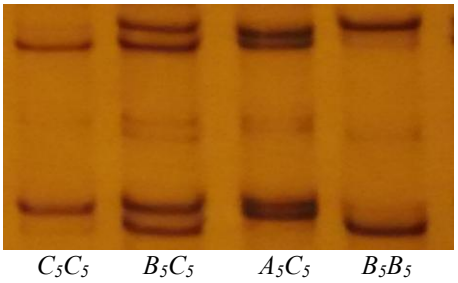

Figure 11; Variants of UCP1 - Intron 5

The most prominent allele was A with a frequency of 63% compared to frequencies of 15% and 22% for B and C alleles respectively (see **Error! Reference source not found.**). The genotypes identified during this study were AA, AB, AC, BB, BC and CC as with UCP1 Y, with BB, BC and CC the most commonly observed (Figure 12).

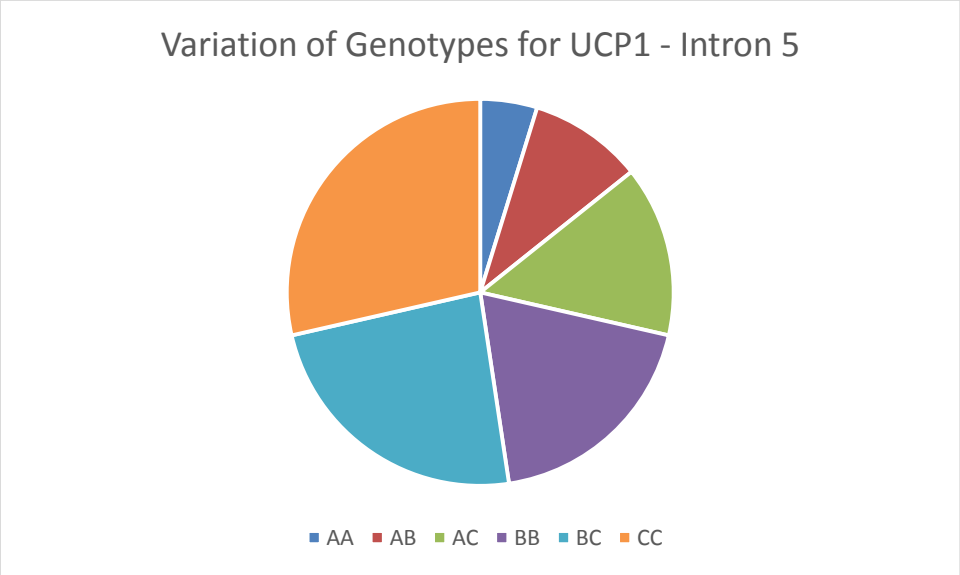

Figure 12; Genotypic Variation of UCP1 Intron 5 in Romney Sheep

4.2.1 Relationship between UCP1 Intron 5 and Sire

A shown in Table 5, the correlation between the expression of UCP1 intron 5 and the sire of individuals was observed to be significant ($P<0.05$). A correlation coefficient of 37.08% was produced through analysis of variance.

Table 5; ANOVA Analysis of UCP1 Intron 5 and Sire

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Ram ID	16	951.4	59.461	40.44	0.000
Error	1098	1614.3	1.470		
Total	1114	2565.6			

Following numeric scaling of the genotypes, the means produced are shown in Figure 13 and have a pooled standard deviation of 1.21.

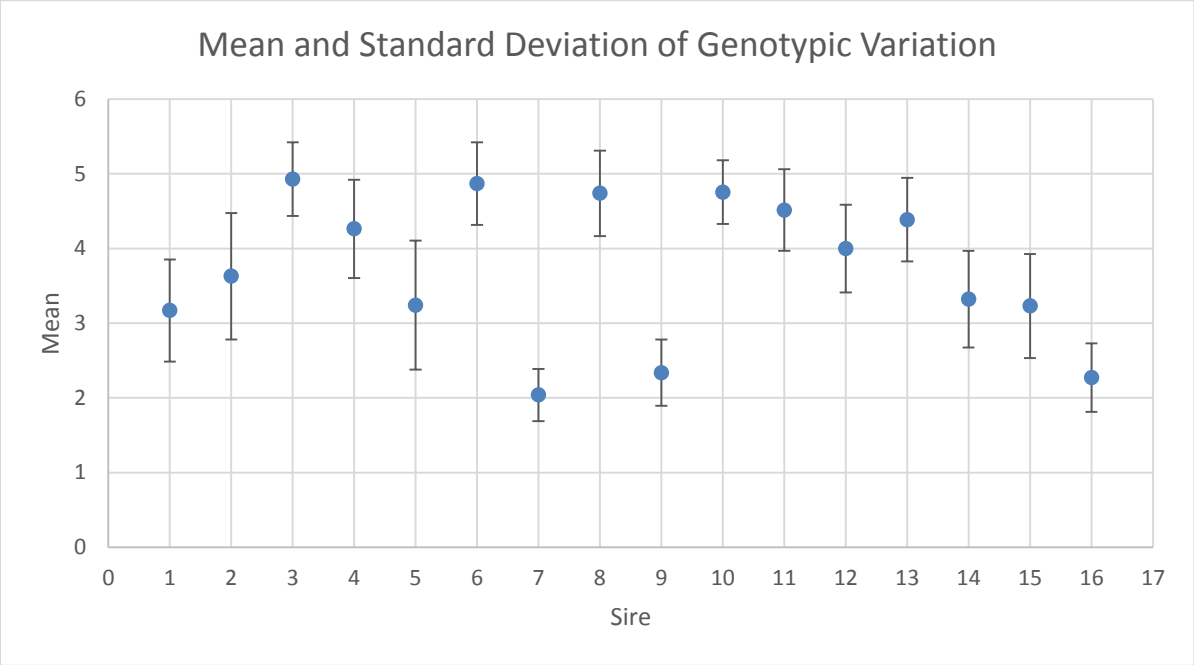

Figure 13; Means and Standard Deviations of UCP1 Intron 5 between Sires

Note; Means and Standard Deviations of each sire are determined from numeric scaling of each genotype as follows;

- aa = 1
- ab = 2
- ac = 3
- bb = 4
- bc = 5
- cc = 6

4.2.2 Relationship between UCP1 Intron 5 and Sex

No significant influence of sex upon UCP1 intron 5 was observed (see Table 6) as both ewe and ram groups had similar means and standard deviations (Table 7).

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sex	1	1.16	1.158	0.50	0.478
Error	1116	2569.23	2.302		
Total	1117	2570.39			

Table 6; ANOVA Output of UCP1 Intron 5 vs. Sex Relationship

Table 7; Mean and Standard Deviation of Relationship between UCP1 - Intron 5 and Sex

Sex	N	Mean	Standard Deviation
Ewe	550	3.8018	1.5278
Ram	568	3.8662	1.5071

4.3 Correlation between UCP1 Y and UCP1 Intron 5 Gene

Comparison between the Y region and the intron 5 region of UCP1 revealed a significant correlation between the two sets of genotypes with an R^2 value of 36.06% and a P value less than 0.005 (Table 8).

Table 8; ANOVA Output of UCP1-Y vs. UCP1 Intron 5 Relationship

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Coded UCP1-Y	5	927.3	185.453	125.52	0.000
Error	1113	1644.5	1.477		
Total	1118	2571.7			

In particular, CC and cc genotypes of UCP1 Y and UCP1 intron 5 had a high correlation between each other as can be seen in Figure 14.

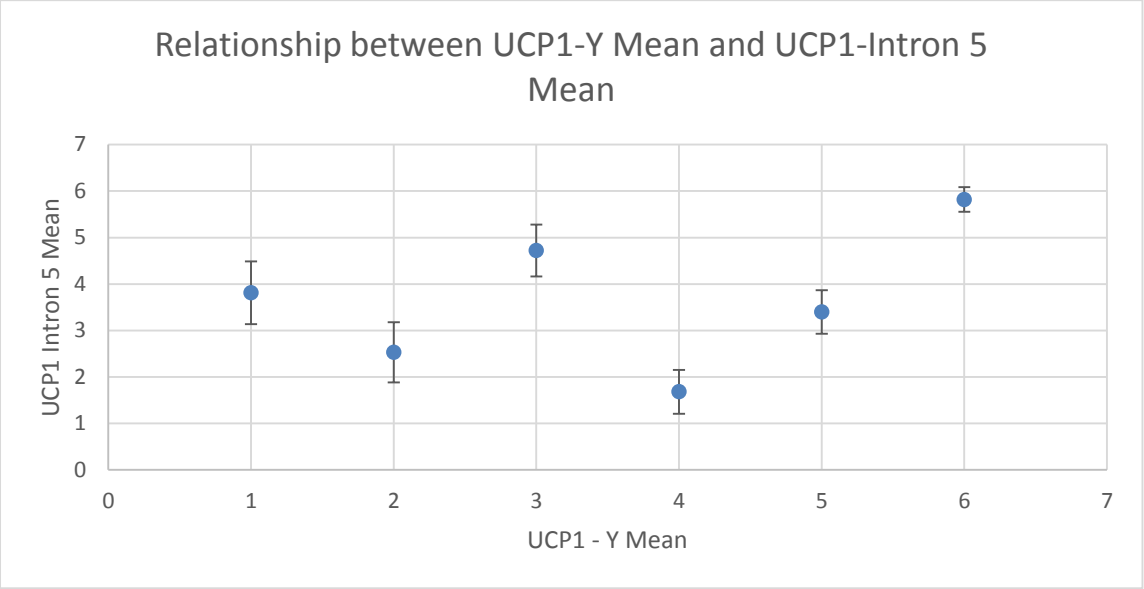

Figure 14; Relationship between UCP1 - Y Gene and UCP1 - Intron 5 Gene
Note; Coding of UCP1-Y and UCP1 intron 5 means are as described in Figure 10 and Figure 13.

4.4 PRKAG3 Gene

The genotypic variation of PRKAG3 observed between breeds resulted in two variants; A and B, with allele frequencies higher for the A allele as opposed to the B allele (72% and 28% respectively). Three combinations resulted from these alleles and the visual appearance of these genotypes can be seen in Figure 15.

Figure 15; PRKAG3 PCR-SSCP results
Note; in order of left to right; aa, bb, ab

The most common occurrence of genotype was aa as can be observed in Figure 16.

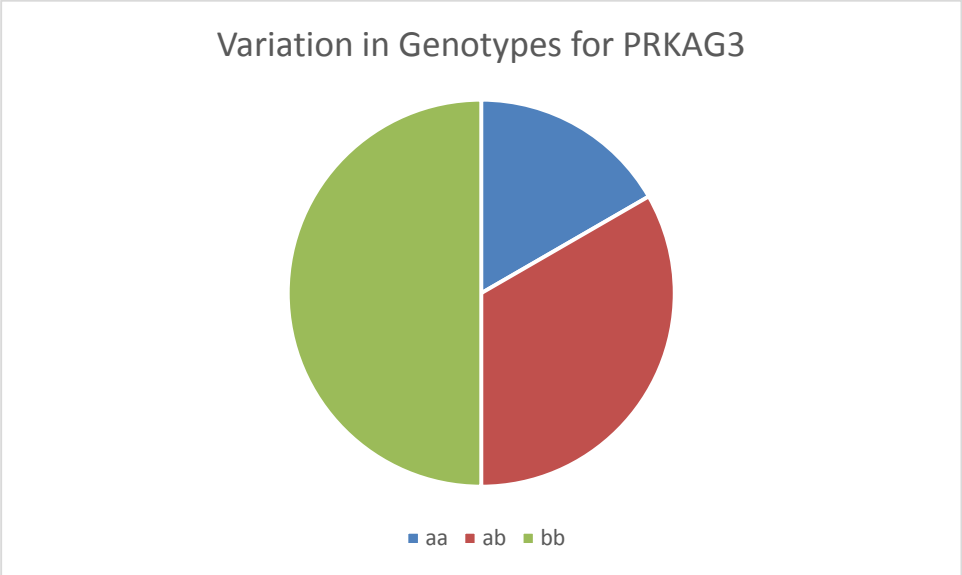

Figure 16; Genotypic Variation of PRKAG3 in Sheep

4.4.1 Relationship between PRKAG3 and Breed

Breed had a significant influence upon PRKAG3 genotype with a P value less than 0.005 (Table 9).

Table 9; ANOVA Output of PRKAG3 and Breed Relationship

```
Analysis of Variance

Source   DF  Adj SS  Adj MS  F-Value  P-Value
breed    16   40.61  2.5382     4.59    0.000
Error   162   89.63  0.5533
Total   178  130.25
```

With similar numerical scaling applied to the UCP1 regions analysed, the means and standard deviations of each breed varied as shown in Figure 17.

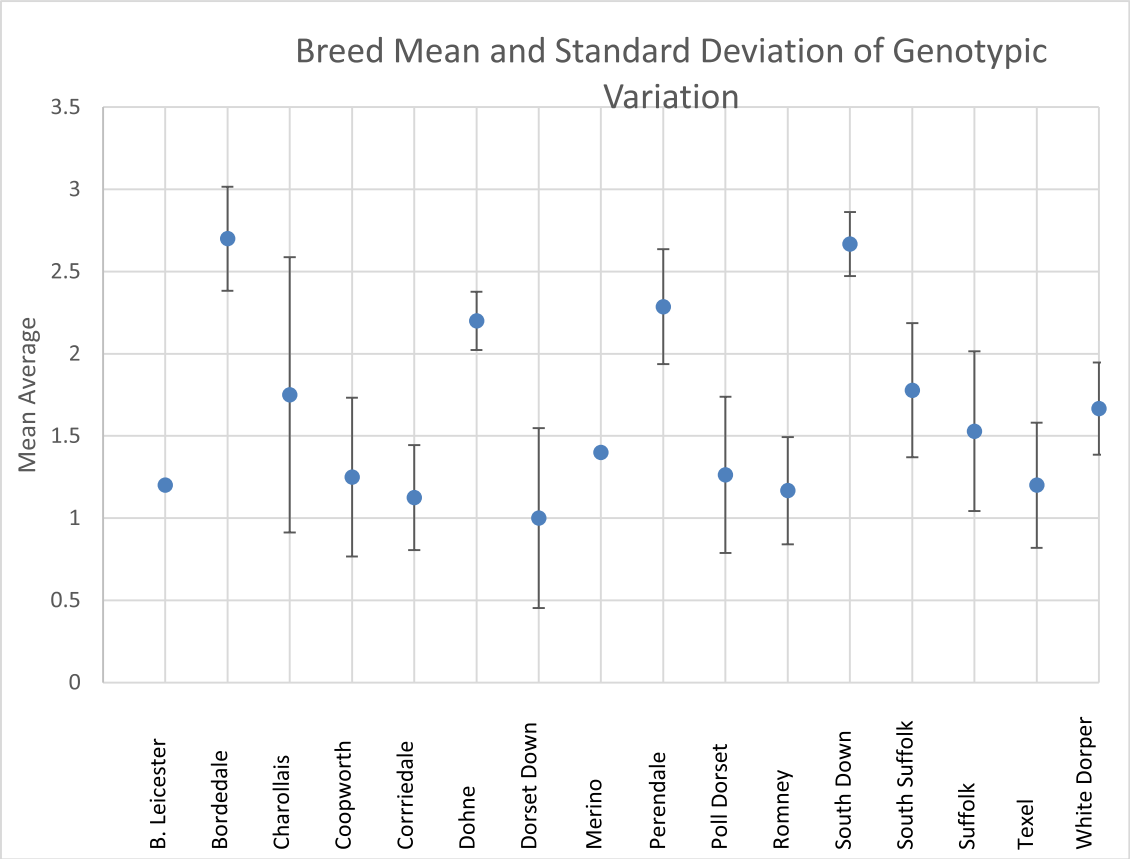

Figure 17; Variation in PRKAG3 between Sheep Breed

Note: The mean of each sheep breed is calculated from the occurrence of genotypes following numeric scaling as follows;

- AA = 1
- AB = 2
- BB = 3

Standard deviations were lowest for Border Leicester and Merino breeds with the largest degree of variation in genotype seen in Charollais and Poll Dorset breeds.

4.4.2 Relationship between PRKAG3 and Breed Purpose

The correlation between expression of PRKAG3 genotypes and the intended purpose of each breed was found to be not significant with a high P value (Table 10) and a correlation coefficient of 0.23% .

Table 10; ANOVA Output of PRKAG3 Gene and Breed Purpose

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Purpose	2	0.305	0.1523	0.21	0.814
Error	176	129.941	0.7383		
Total	178	130.246			

Means between meat, wool and dual purpose breeds ranged between 1.45 and 1.55 and similar standard deviations (Figure 18).

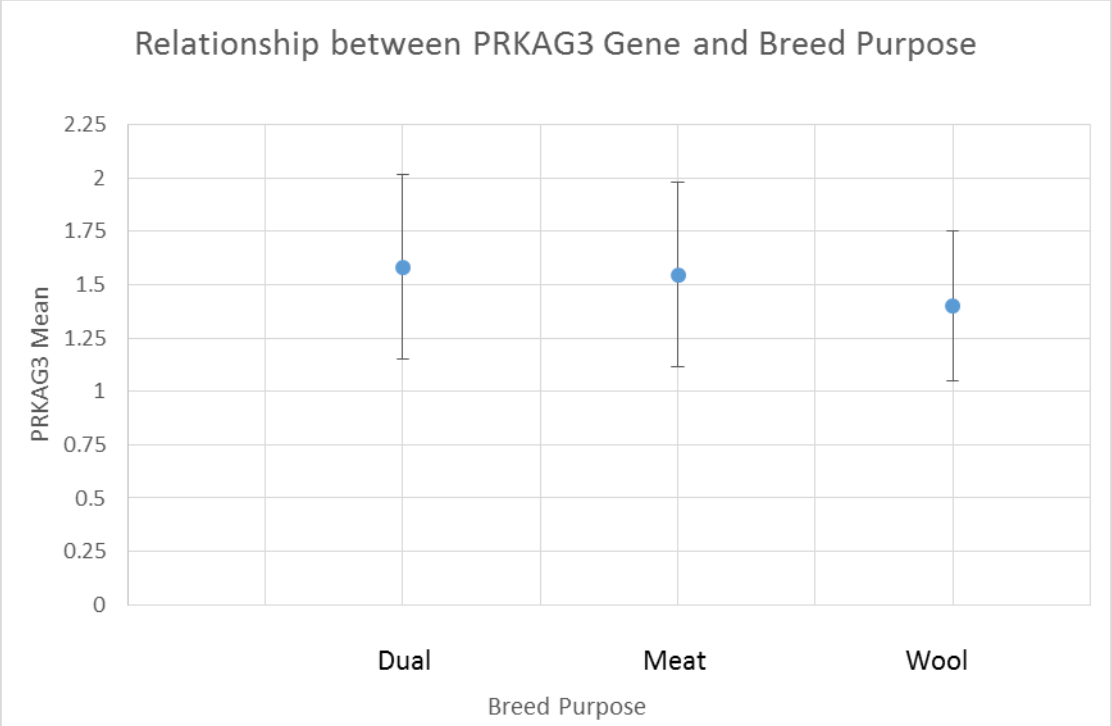

Figure 18; Relationship between PRKAG3 Gene and Breed Purpose
Note; Coding of PRKAG3 mean is as is described in Figure 17

Chapter 5

Discussion

5.1 UCP1

The aim of this study was to reiterate whether the variation previously identified in research is influential in growth and carcass composition traits or due to selection influences such as sire or population. Yang et al, (2014), identified three regions of variation in the gene, namely; two variants within intron 2, and three variants within the promoter region.

5.1.1 Variation of UCP1 in the promoter region and intron 5 among Romney sheep

The level of variation reported within the promoter region of UCP1 by Yang et al, (2014) was also found in this study. Three nucleotide substitutions; A, B and C were identified and these varied among all individuals from all sires analysed. In contrast to the research by Yang et al, (2014), the frequencies with which the individual genotype variant A was present among the individuals analysed, was substantially lower in this study (53% and 25% respectively). Whereas B and C variants were higher than previous studies (see Appendix A.1. 1). The low frequency of the C variant in particular was thought to be due to selection pressures in sheep farming systems against over-fat carcasses (Yang et al, 2014), however the higher frequency of the C variant in this study suggests this may not be the case. The frequency with which each genotype was observed also differed to previously reported results, most notably an increase of BB and BC genotypes (Appendix A.1. 2).

Analysis of UCP1 Y variation among the 17 sires, produced a significant result which indicates that much of the divergence in phenotype previously reported (Yuan et al, 2012; Yang et al, 2014) may in fact be due to the influence of sire. This is opposed to previous hypotheses suggesting that the variants of UCP1, namely the presence of the B allele could have significant implications upon economically important growth and carcass traits in sheep.

Similar variation was observed in the intron 5 region of UCP1 as with the promoter region. The influence of sire on the variation observed was also significant ($P < 0.001$) and a correlation coefficient value of 37.08% produced from analysis of variance is indicative of the high level of influence this may have upon phenotypes.

As expected, no relationship was observed between the expression of either UCP1 Y or UCP1 intron 5 genotypes and the sex of the individuals studied. Correlations between the genotypes of the two

regions of UCP1 analysed were significant ($P < 0.001$) with many individuals expressing the CC genotype for UCP1 Y also being homozygous for the c allele of UCP1 intron 5.

5.2 PRKAG3

5.2.1 Variation of PRKAG3 gene

The aim this study was to identify the degree of variation that occurs within the PRKAG3 gene, as it has potential implications for the growth and carcass composition of sheep.

The two variants a and b observed in the sequencing of PRKAG3 were similar to previous research of the gene in sheep. Yang et al, (2015) also identified two variants in exon 3 of the gene. The allele frequencies were 72% and 28% for a and b respectively. The most common genotype for PRKAG3 observed in this study was aa and ab and this is reflected in the average mean between breeds following numerical scaling. Standard deviations of PRKAG3 among breeds was 0.7438 with low values occurring in Border Leicester and Merino breeds indicating very little variation within those breeds . ANOVA analysis indicated that there was a significant relationship between sheep breeds and the genotype observed within each breed. In particular, Bordedale, Coopworth, Corriedale, Southdown and Suffolk had significance values less than 0.05, while Perendale had a significance value less than 0.01.

As PRKAG3 is thought to have phenotypic effects involving fat deposition, it seemed appropriate to analyse the effect the variation observed had upon the purpose (meat production, wool production or dual purpose) of each breed. No relationship was observed ($P=0.814$) with a low correlation coefficient produced ($R^2= 0.23\%$).

5.3 Limitations of this Study in UCP1 and PRKAG3

5.3.1 UCP1

The variation observed in UCP1 in this study was influenced by the sire of the individuals which could indicate that the previous phenotypic effects observed could be the result of natural genetic effects or breeding processes employed by farmers.

Differences between the allele frequencies observed in Suffolk and Romney sheep were observed in the study by Yang et al, (2014) and as such, a larger degree of variation may be seen if a greater diversity of breeds was utilised, and a larger number of each breed used. In addition, the variation observed in intron 5 has no previous research to support its importance in terms of meat quality traits. As such, it may have little relevance in terms of improving sheep traits.

As there are other genes that are in the vicinity of UCP1 in sheep, it is also possible that the phenotypic results observed in earlier studies could be influenced by other genetic factors.

5.3.2 PRKAG3

Several limitations exist in this study of variation within the PRKAG3 gene. The number of blood samples from each breed ranged from 5 to 20 and as such, this was the greatest limitation on this study. This number is not great enough to be fully representative of all the variation that may be seen in each breed. In addition to this, as the number of samples used in this study was limited, there were cases where for some less common breeds, all samples were sourced from the same farm. This could result in less variation due to in breeding or line breeding and as such, the variation observed may be more attributable to congenital effects. This is supported by research carried out by Kijas et al, (2009) who identified a genetic distance of between 0.16 and 0.31 within sheep breeds and a genetic distance of 0.265-0.355 between *Ovis aries* breeds. As there was little information accompanying the FTA card blood samples supplied by the Lincoln University genotyping department, it was not possible to analyse any potential relationships between PRKAG3 and other factors such as sex.

To gain a better understanding as to the implications of the PRKAG3 gene, it would be necessary to measure traits that are potentially influenced by the expression of genotypes that have been observed.

5.4 Implications of this study and potential future directions for genes involved with growth rate and carcass composition traits in sheep

5.4.1 UCP1

Yang et al, (2014) indicated that the presence of the B variant in the UCP1 promoter region was correlated to increased lean meat yield in the hind-leg, decreased V-GR and decreased lean loin meat yield. This high frequency with which the B variant was observed in the UCP1 Y analysis indicates that these individuals may be predisposed to greater lean meat yield than their counterparts with AA, AC or CC genotypes. However, as the variation observed within this study differs considerably from previous studies, and given the relationship between sire and genotype, previous results may have been due to other factors. These could include a high level of natural genetic similarity between the individuals initially studied resulting from breeding programmes involving line breeding or inbreeding.

Further research into UCP1 is required in order to ensure that all potential regions of variation that may affect growth rate and compositional traits of sheep have been fully investigated. Phenotypical data for analysis in combination with intron 5 genotypes is necessary to quantify any relationship that a given variant may have on physical attributes. Although the B variant of UCP1 Y, which has previously researched associations with growth and carcass traits, was more prolific as reported in previous studies of Romney sheep, further research is required. A wide-ranging study into the gene across breeds, alongside phenotypic measurements may summarise the potential of the promoter region of UCP1.

5.4.2 PRKAG3

The results observed not only in this study, but previous research surrounding PRKAG3 may be due not specifically to the PRKAG3 gene or the mutational variations observed. Several other genes are in a close proximity to PRKAG3 such as GDF8, SCLA11A1 and INHA (Johnson et al, 2005). If linkage between PRKAG3 region and other nearby QTL is occurring then the phenotypic results may not be due in whole to the variations observed in this study. The variation within the PCR – SSCP outputs from the PRKAG3 gene analysed with the primers outlined in this study showed some variation between these genotypes. Further investigation is needed in order to quantify this level of variation and whether it has any observable phenotypical effects in sheep.

The differences in PRKAG3 genotype observed between breeds is in line with genetic distance calculation carried out by Kijas et al, (2009). In consideration of research carried out with pigs (Ryan et al, 2012) concerning the PRKAG3 gene, it could be hypothesised that expression of the PRKAG3 variation that results in increased glycogen in skeletal and other muscles may differ between breeds. Conversely, the analysis carried out for breed purpose indicates no difference between breeds that are classed as meat producers versus those that are classed as wool producers. This could be the result of interbreeding between breeds or the selection techniques employed by individual farmers.

Chapter 6

Conclusion

The variation observed in both UCP1 and PRKAG3 genes indicate that further research is required to quantify their potential effects upon economically important traits such as carcass composition and growth rate in the *Ovis aries* breed. The variation in both observed genes was similar to previously published results, however differences in interactions between the genes and other factors were seen. The sire of individuals studied appears to have a significant bearing upon the variation observed within UCP1, as such, previous associations with sheep production traits may be due to congenital effects as opposed to genetic variation within the gene sequence. The two variants of PRKAG3 were observed to be influenced by the breed of sheep. However, as a certain degree of relatedness exists between most, if not all breeds of sheep, further investigation with the use of greater sample numbers of each breed is required to determine whether results observed in this study are accurate.

Appendix A UCP1

A.1 Allele and Genotype Frequencies

Appendix A.1. 1; Allele Frequencies for UCP1

	A	B	C
UCP1 Y	25%	36%	39%
UCP1 Intron 5	63%	15%	22%

Appendix A.1. 2; Genotype Frequencies UCP1 Y

Genotype Frequencies	
AA	7%
AB	17%
AC	20%
BB	12%
BC	32%
CC	13%
	100%

A.2 Tukey Pairwise Comparisons

Appendix A2. 1; UCP1 Y vs. Ram ID

Ram ID	N	Mean	Grouping
Doughboy 45/04	70	3.771	A
Glenleith 25/02	65	2.923	B
Waidale 618/04	70	2.900	B
Mana 83/04	65	2.800	B C
Sudeley 102/04	64	2.797	B C
Hermiston 22/04	83	2.747	B C
Banklea 217/00	53	2.491	B C D
Mana 90/01	77	2.468	B C D
Glenleith 252/04	54	2.259	B C D E
Longridge 626/02	65	2.062	C D E
Totaranui 376/02	74	2.000	D E
Snowlea 192/02	68	1.809	D E
Tanlet 547/02	56	1.714	D E
Braebank 67/03	78	1.6282	E
Offord 414/01	74	1.554	E
Leeds Lodge 26/03	46	1.500	E
Lammerlaw 77/04	50	1.480	E

Means that do not share a letter are significantly different.

Appendix A2. 2; UCP1 Y vs. Sex

Sex	N	Mean	Grouping
R	565	2.3504	A
E	550	2.2745	A

Means that do not share a letter are significantly different.

Appendix A2. 3; UCP1 in5 vs. Ram ID

Ram	ID	N	Mean	Grouping					
Doughboy	45/04	70	4.929	A					
Hermiston	22/04	84	4.869	A					
Mana	90/01	77	4.753	A					
Leeds Lodge	26/03	46	4.739	A	B				
Mana	83/04	66	4.636	A	B				
Offord	414/01	74	4.514	A	B				
Sudeley	102/04	65	4.385	A	B				
Glenleith	25/02	65	4.262	A	B	C			
Braebank	67/03	78	3.628			C	D	E	
Tanlet	547/02	56	3.321				D	E	
Glenleith	252/04	54	3.241				D	E	
Snowlea	192/02	68	4.000		B	C	D		
Totaranui	376/02	74	3.230					E	
Banklea	217/00	53	3.170					E	
Longridge	626/02	65	2.338						F
Waidale	618/04	70	2.271						F
Lammerlaw	77/04	50	2.0400						F

Appendix A2. 4; UCP1 in5 vs. Sex

Sex	N	Mean	Grouping
R	568	3.8662	A
E	550	3.8018	A

Means that do not share a letter are significantly different.

Appendix A2. 5; UCP1 Y vs. UCP1 in5

Coded UCP1-Y	N	Mean	Grouping		
6	49	5.8163	A		
3	314	4.7197		B	
1	444	3.8131			C
5	77	3.403			C
2	210	2.5286		D	
4	25	1.680			E

A.3 Ovine UCP1 Sequence

TCGAGGGAGGGCAAGCAGGCGCCGCTGTACCGACTCCGCCACCTGCCACCTGGCCCGCTGCAGCCCCCTG
CCTGCCGCCCCCACTGACCAGAAGTCGGAGAGGACGGGTCTGCTGCCCGGCCGCGCAGGAGTGAGAAGCC
AGGCAGCACTTCCACCTTCGGGACCGAAGCCCTGCTCCCCTTGCGCCGGAGTCCGCGTTGAGTCAGGATG
GTGGGACACGCAGCGACAGACGTGCCCCCTACCATGGCAGTCAAGATCTTCTCGGCGGGGGTGGCGGCCT
GCGTGGCTGACATAATCACCTTCCCGCTGGACACCGCCAAAGTCCGGCTACAGGTAGGGAGCGCCGCGGG
CAAGGGGAGGAGCCTGGGGCAGAGAGGGGACTACTGTGTGCGCCCCTTTGACTCTGGCTTCGGTTTTACC
ATCCTTTCTCACGTTAGATAGAGCAGTGGCCACGTTCAGAGTTTGCCTTCACTGGATGGATGCTTTAGGG
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CTTCCTGGGGGTGGGACAGTGAGGTGCGGGATGGGGAGGATGTTCAAAGTATGCCTAGTAGCCAGATTCT
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TCTTGGCTCAAGTTTTCTCCATTGAGGACAGCTTGATGCCAACCTTTGTGTTTTTCCTCACTAGGTAGGA
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AAACGAAGTTTCCTTTTTATTTATTAACCCCATTGTCAGTTAATATATTCAATAAAATATTGCTAATCTC
T

A.4 UCP1 Raw Data

Year	Lamb ID	Ewe ID	RAM ID	Sex	UCP1-in5	UCP1-Y
2006 SI	66	701/04	Waidale 618/04	R	AC	ab
2006 SI	68	847/04	Waidale 618/04	E	AB	ab
2006 SI	99	756/04	Waidale 618/04	R	AB	ab
2006 SI	118	717/04	Waidale 618/04	R	AB	ab
2006 SI	119	717/04	Waidale 618/04	R	AC	bc
2006 SI	124	82/04	Waidale 618/04	E	AC	bb
2006 SI	142	597/04	Waidale 618/04	R	AC	bc
2006 SI	143	597/04	Waidale 618/04	R	AC	bc
2006 SI	197	681/04	Waidale 618/04	R	AC	ab
2006 SI	204	395/04	Waidale 618/04	R	AC	bc
2006 SI	205	395/04	Waidale 618/04	E	AC	bc
2006 SI	260	526/04	Waidale 618/04	E	AB	ab
2006 SI	261	526/04	Waidale 618/04	E	AB	ab
2006 SI	314	276/04	Waidale 618/04	E	AC	ab
2006 SI	323	628/04	Waidale 618/04	E	AC	bc
2006 SI	324	643/04	Waidale 618/04	R	AB	ab
2006 SI	325	643/04	Waidale 618/04	E	AC	ab
2006 SI	381	646/04	Waidale 618/04	R	AB	ab
2006 SI	382	646/04	Waidale 618/04	R	AC	bc
2006 SI	413	718/04	Waidale 618/04	E	AC	bc
2006 SI	414	718/04	Waidale 618/04	E	AC	bc
2006 SI	431	365/04	Waidale 618/04	R	AC	ab
2006 SI	432	365/04	Waidale 618/04	E	AA	bb
2006 SI	451	686/04	Waidale 618/04	E	AB	ab
2006 SI	452	686/04	Waidale 618/04	E	AB	ab
2006 SI	471	742/04	Waidale 618/04	R	AB	bc
2006 SI	472	742/04	Waidale 618/04	R	AC	bc
2006 SI	473	354/04	Waidale 618/04	E	AC	bb

2006 SI	474	354/04	Waidale 618/04	E	AA	bb
2006 SI	502	5 /04	Waidale 618/04	E	AB	ab
2006 SI	504	639/04	Waidale 618/04	E	AB	ab
2006 SI	555	708/04	Waidale 618/04	R	AB	ab
2006 SI	556	708/04	Waidale 618/04	R	AB	bb
2006 SI	602	614/04	Waidale 618/04	E	AB	ab
2006 SI	645	259/04	Waidale 618/04	E	AC	ab
2006 SI	715	41/04	Waidale 618/04	E	AC	bc
2006 SI	722	77/04	Waidale 618/04	R	AB	ab
2006 SI	781	849/04	Waidale 618/04	R	AC	ab
2006 SI	782	849/04	Waidale 618/04	E	AC	ab
2006 SI	803	76/04	Waidale 618/04	E	AC	bb
2006 SI	812	253/04	Waidale 618/04	E	AB	ab
2006 SI	919	282/04	Waidale 618/04	E	AA	bb
2006 SI	926	209/04	Waidale 618/04	E	AC	ab
2006 SI	1011	796/04	Waidale 618/04	E	AB	ab
2006 SI	1012	796/04	Waidale 618/04	E	AB	ab
2006 SI	1018	747/04	Waidale 618/04	R	AC	bc
2006 SI	1019	747/04	Waidale 618/04	E	AC	bc
2006 SI	1050	754/04	Waidale 618/04	R	AB	ab
2006 SI	1068	428/04	Waidale 618/04	R	AB	ab
2006 SI	1069	428/04	Waidale 618/04	E	AB	ab
2006 SI	41	645/04	Totaranui 376/02	E	BB	aa
2006 SI	75	425/04	Totaranui 376/02	R	BB	aa
2006 SI	76	425/04	Totaranui 376/02	E	BB	aa
2006 SI	91	154/04	Totaranui 376/02	E	BB	aa
2006 SI	131	68/04	Totaranui 376/02	R	BB	aa
2006 SI	147	330/04	Totaranui 376/02	R	BC	aa
2006 SI	170	19 /04	Totaranui 376/02	E	BC	aa
2006 SI	175	805/04	Totaranui 376/02	R	BB	aa
2006 SI	176	805/04	Totaranui 376/02	E	BC	aa
2006 SI	319	554/04	Totaranui 376/02	R	BC	aa
2006 SI	321	554/04	Totaranui 376/02	E	BC	aa
2006 SI	393	807/04	Totaranui 376/02	E	AA	bb
2006 SI	394	807/04	Totaranui 376/02	E	AA	bb
2006 SI	396	582/04	Totaranui 376/02	E	BB	aa
2006 SI	521	175/04	Totaranui 376/02	R	BB	ab
2006 SI	589	570/04	Totaranui 376/02	E	BB	aa
2006 SI	599	834/04	Totaranui 376/02	E	BB	aa
2006 SI	667	734/04	Totaranui 376/02	R	AA	bb
2006 SI	721	212/04	Totaranui 376/02	E	BB	aa
2006 SI	758	487/04	Totaranui 376/02	E	CC	aa
2006 SI	759	487/04	Totaranui 376/02	E	CC	aa
2006 SI	903	720/04	Totaranui 376/02	E	BB	aa
2006 SI	1034	206/04	Totaranui 376/02	E	BB	aa

2006 SI	1101	725/04	Totaranui 376/02	R	BB	aa
2006 SI	1146	705/04	Totaranui 376/02	E	BB	aa
2006 SI	1147	705/04	Totaranui 376/02	E	BB	aa
2006 SI	1152	705/04	Totaranui 376/02	R	BB	aa
2006 SI	1231	531/04	Totaranui 376/02	R	BB	aa
2006 SI	1261	14 /04	Totaranui 376/02	R	BB	aa
2006 SI	1283	534/04	Totaranui 376/02	E	BB	aa
2006 SI	10	704/04	Tanlet 547/02	R	BC	aa
2006 SI	11	704/04	Tanlet 547/02	R	BC	aa
2006 SI	46	123/04	Tanlet 547/02	E	BB	ab
2006 SI	113	81/04	Tanlet 547/02	R	BC	ab
2006 SI	185	412/04	Tanlet 547/02	R	BC	ac
2006 SI	186	412/04	Tanlet 547/02	R	BC	ac
2006 SI	297	36/04	Tanlet 547/02	E	BC	ac
2006 SI	344	567/04	Tanlet 547/02	R	BB	aa
2006 SI	368	149/04	Tanlet 547/02	R	BB	aa
2006 SI	416	317/04	Tanlet 547/02	E	BC	ac
2006 SI	519	33/04	Tanlet 547/02	E	BC	ac
2006 SI	580	599/04	Tanlet 547/02	R	BC	ac
2006 SI	581	599/04	Tanlet 547/02	E	BB	aa
2006 SI	632	316/04	Tanlet 547/02	R	BB	aa
2006 SI	654	541/04	Tanlet 547/02	R	BB	aa
2006 SI	655	541/04	Tanlet 547/02	E	BC	aa
2006 SI	664	811/04	Tanlet 547/02	E	BB	aa
2006 SI	932	100/04	Tanlet 547/02	R	BB	aa
2006 SI	961	269/04	Tanlet 547/02	E	BB	aa
2006 SI	1044	433/04	Tanlet 547/02	R	BC	ac
2006 SI	1074	315/04	Tanlet 547/02	R	BB	aa
2006 SI	1090	492/04	Tanlet 547/02	R	BC	aa
2006 SI	1091	492/04	Tanlet 547/02	E	BB	aa
2006 SI	1234	758/04	Tanlet 547/02	R	BC	ac
2006 SI	1242	808/04	Tanlet 547/02	R	BC	ac
2006 SI	1253	470/04	Tanlet 547/02	E	BB	aa
2006 SI	3147	234/04	Tanlet 547/02	R	BB	aa
2006 SI	3155	359/04	Tanlet 547/02	R	BB	aa
2006 SI	3179	69/04	Tanlet 547/02	R	BB	aa
2006 SI	27	263/04	Sudeley 102/04	E	BB	aa
2006 SI	37	453/04	Sudeley 102/04	R	CC	cc
2006 SI	38	453/04	Sudeley 102/04	E	BC	aa
2006 SI	54	437/04	Sudeley 102/04	R	BC	aa
2006 SI	95	447/04	Sudeley 102/04	E	CC	cc
2006 SI	128	27 /04	Sudeley 102/04	E	BC	aa
2006 SI	183	483/04	Sudeley 102/04	E	BB	aa
2006 SI	251	694/04	Sudeley 102/04	E	CC	cc
2006 SI	419	6 /04	Sudeley 102/04	R	BB	aa

2006 SI	478	743/04	Sudeley 102/04	R	CC	cc
2006 SI	509	523/04	Sudeley 102/04	R	BB	aa
2006 SI	538	799/04	Sudeley 102/04	R	BB	aa
2006 SI	574	205/04	Sudeley 102/04	R	BC	aa
2006 SI	575	205/04	Sudeley 102/04	R	BB	aa
2006 SI	651	502/04	Sudeley 102/04	R	CC	cc
2006 SI	652	780/04	Sudeley 102/04	R	BB	aa
2006 SI	653	780/04	Sudeley 102/04	R	BB	aa
2006 SI	685	349/04	Sudeley 102/04	R	CC	cc
2006 SI	827	757/04	Sudeley 102/04	E	BC	aa
2006 SI	828	757/04	Sudeley 102/04	E	BB	aa
2006 SI	854	790/04	Sudeley 102/04	R	BB	aa
2006 SI	855	790/04	Sudeley 102/04	R	CC	cc
2006 SI	891	361/04	Sudeley 102/04	R	CC	bc
2006 SI	895	345/04	Sudeley 102/04	E	BB	aa
2006 SI	941	730/04	Sudeley 102/04	E	BB	aa
2006 SI	942	730/04	Sudeley 102/04	E	BB	aa
2006 SI	985	602/04	Sudeley 102/04	R	BC	aa
2006 SI	986	602/04	Sudeley 102/04	E	CC	aa
2006 SI	990	636/04	Sudeley 102/04	R	CC	cc
2006 SI	1054	624/04	Sudeley 102/04	E	CC	ac
2006 SI	1181	831/04	Sudeley 102/04	E	CC	cc
2006 SI	1182	831/04	Sudeley 102/04	E	CC	cc
2006 SI	1285	851/04	Sudeley 102/04	R	CC	cc
2006 SI	3128	185/04	Sudeley 102/04	E	BB	aa
2006 SI	36	70/04	Snowlea 192/02	R	BB	ac
2006 SI	59	548/04	Snowlea 192/02	R	BB	aa
2006 SI	60	548/04	Snowlea 192/02	R	BC	ac
2006 SI	132	408/04	Snowlea 192/02	R	BB	aa
2006 SI	133	408/04	Snowlea 192/02	E	BB	aa
2006 SI	134	690/04	Snowlea 192/02	R	AB	ab
2006 SI	135	690/04	Snowlea 192/02	E	AB	ab
2006 SI	153	393/04	Snowlea 192/02	E	BB	aa
2006 SI	178	632/04	Snowlea 192/02	E	BC	aa
2006 SI	179	632/04	Snowlea 192/02	E	AB	ab
2006 SI	219	35/04	Snowlea 192/02	E	BB	aa
2006 SI	221	50/04	Snowlea 192/02	R	BC	ac
2006 SI	222	610/04	Snowlea 192/02	R	BC	ab
2006 SI	223	610/04	Snowlea 192/02	E	BC	ab
2006 SI	250	546/04	Snowlea 192/02	R	BC	ac
2006 SI	253	546/04	Snowlea 192/02	R	BC	ac
2006 SI	334	342/04	Snowlea 192/02	R	BC	ac
2006 SI	335	342/04	Snowlea 192/02	R	BC	ac
2006 SI	356	46/04	Snowlea 192/02	R	BB	aa
2006 SI	357	98/04	Snowlea 192/02	R	BC	ac

2006 SI	358	274/04	Snowlea 192/02	R	BC	ac
2006 SI	363	272/04	Snowlea 192/02	R	BB	aa
2006 SI	399	407/04	Snowlea 192/02	R	BC	ac
2006 SI	400	407/04	Snowlea 192/02	R	BB	aa
2006 SI	401	435/04	Snowlea 192/02	E	BC	ac
2006 SI	402	435/04	Snowlea 192/02	E	BB	aa
2006 SI	411	839/04	Snowlea 192/02	R	BB	aa
2006 SI	412	839/04	Snowlea 192/02	E	AB	ab
2006 SI	435	777/04	Snowlea 192/02	R	BC	ab
2006 SI	436	777/04	Snowlea 192/02	R	BC	ab
2006 SI	459	601/04	Snowlea 192/02	R	BB	aa
2006 SI	460	601/04	Snowlea 192/02	E	BB	aa
2006 SI	479	762/04	Snowlea 192/02	R	BC	aa
2006 SI	520	141/04	Snowlea 192/02	R	BB	aa
2006 SI	561	430/04	Snowlea 192/02	R	AB	ab
2006 SI	562	430/04	Snowlea 192/02	R	AB	ab
2006 SI	566	192/04	Snowlea 192/02	E	BB	aa
2006 SI	572	105/04	Snowlea 192/02	R	BB	aa
2006 SI	665	264/04	Snowlea 192/02	R	BC	ab
2006 SI	666	264/04	Snowlea 192/02	E	BB	aa
2006 SI	741	443/04	Snowlea 192/02	E	BB	aa
2006 SI	785	348/04	Snowlea 192/02	E	BB	aa
2006 SI	786	348/04	Snowlea 192/02	E	BC	ac
2006 SI	808	111/04	Snowlea 192/02	E	BB	aa
2006 SI	911	377/04	Snowlea 192/02	E	BC	ac
2006 SI	912	377/04	Snowlea 192/02	E	BC	ac
2006 SI	922	25 /04	Snowlea 192/02	E	BB	aa
2006 SI	964	631/04	Snowlea 192/02	E	AB	ac
2006 SI	991	375/04	Snowlea 192/02	R	BC	ac
2006 SI	992	375/04	Snowlea 192/02	E	BB	aa
2006 SI	1092	677/04	Snowlea 192/02	E	BC	ac
2006 SI	1093	677/04	Snowlea 192/02	E	BC	ac
2006 SI	1157	436/04	Snowlea 192/02	R	BB	aa
2006 SI	1158	436/04	Snowlea 192/02	E	BC	ac
2006 SI	1189	357/04	Snowlea 192/02	R	BB	aa
2006 SI	1190	357/04	Snowlea 192/02	E	BB	aa
2006 SI	1212	39/04	Snowlea 192/02	E	BB	aa
2006 SI	1237	297/04	Snowlea 192/02	E	BC	ac
2006 SI	1264	167/04	Snowlea 192/02	R	BC	ac
2006 SI	3193	800/04	Snowlea 192/02	R	BC	aa
2006 SI	3194	800/04	Snowlea 192/02	E	BC	ac
2006 SI	78	138/04	Offord 414/01	R	BC	aa
2006 SI	82	580/04	Offord 414/01	E	BC	aa
2006 SI	83	580/04	Offord 414/01	E	CC	aa
2006 SI	140	268/04	Offord 414/01	R	BC	aa

2006 SI	188	741/04	Offord 414/01	E	BB	aa
2006 SI	199	9 /04	Offord 414/01	E	CC	ac
2006 SI	206	504/04	Offord 414/01	R	BB	aa
2006 SI	229	296/04	Offord 414/01	R	BB	aa
2006 SI	230	296/04	Offord 414/01	E	BB	aa
2006 SI	241	270/04	Offord 414/01	R	BC	aa
2006 SI	242	270/04	Offord 414/01	E	BC	aa
2006 SI	248	821/04	Offord 414/01	R	BC	aa
2006 SI	249	821/04	Offord 414/01	E	CC	aa
2006 SI	281	595/04	Offord 414/01	E	BB	ab
2006 SI	308	135/04	Offord 414/01	R	BC	aa
2006 SI	316	318/04	Offord 414/01	E	BC	aa
2006 SI	353	670/04	Offord 414/01	E	BC	aa
2006 SI	364	132/04	Offord 414/01	R	BC	aa
2006 SI	369	240/04	Offord 414/01	E	BB	aa
2006 SI	405	559/04	Offord 414/01	E	BC	aa
2006 SI	438	533/04	Offord 414/01	R	BB	aa
2006 SI	453	778/04	Offord 414/01	R	CC	ac
2006 SI	454	778/04	Offord 414/01	E	CC	ac
2006 SI	553	775/04	Offord 414/01	E	BC	aa
2006 SI	573	62/04	Offord 414/01	R	BC	aa
2006 SI	642	280/04	Offord 414/01	E	CC	ac
2006 SI	669	668/04	Offord 414/01	R	BC	aa
2006 SI	688	727/04	Offord 414/01	R	BB	aa
2006 SI	689	727/04	Offord 414/01	R	BC	aa
2006 SI	732	739/04	Offord 414/01	R	CC	aa
2006 SI	733	739/04	Offord 414/01	E	CC	aa
2006 SI	736	769/04	Offord 414/01	R	BC	aa
2006 SI	764	565/04	Offord 414/01	R	BB	aa
2006 SI	825	243/04	Offord 414/01	R	CC	aa
2006 SI	867	746/04	Offord 414/01	R	CC	ac
2006 SI	904	740/04	Offord 414/01	R	BB	aa
2006 SI	906	740/04	Offord 414/01	E	BB	aa
2006 SI	929	257/04	Offord 414/01	R	BC	aa
2006 SI	936	275/04	Offord 414/01	E	BC	aa
2006 SI	958	294/04	Offord 414/01	R	CC	aa
2006 SI	1002	515/04	Offord 414/01	R	BC	aa
2006 SI	1003	515/04	Offord 414/01	R	BB	aa
2006 SI	1028	150/04	Offord 414/01	E	AC	ab
2006 SI	1029	150/04	Offord 414/01	E	AB	ab
2006 SI	1071	388/04	Offord 414/01	R	CC	ac
2006 SI	1094	439/04	Offord 414/01	R	BC	aa
2006 SI	1095	439/04	Offord 414/01	R	BB	aa
2006 SI	1110	854/04	Offord 414/01	R	CC	ac
2006 SI	1111	854/04	Offord 414/01	E	BB	aa

2006 SI	3187	801/04	Offord 414/01	E	BC	aa
2006 SI	3188	801/04	Offord 414/01	R	BC	aa
2006 SI+795:885	79	38/04	Mana 90/01	E	BC	aa
2006 SI	158	665/04	Mana 90/01	R	CC	ac
2006 SI	172	225/04	Mana 90/01	R	BC	aa
2006 SI	173	48/04	Mana 90/01	E	CC	ac
2006 SI	174	126/04	Mana 90/01	E	AC	cc
2006 SI	180	456/04	Mana 90/01	R	BC	aa
2006 SI	210	421/04	Mana 90/01	R	AC	bc
2006 SI	211	421/04	Mana 90/01	R	AC	ab
2006 SI	228	392/04	Mana 90/01	E	CC	ac
2006 SI	282	702/04	Mana 90/01	R	AC	ab
2006 SI	295	254/04	Mana 90/01	R	BC	aa
2006 SI	311	199/04	Mana 90/01	E	BC	aa
2006 SI	377	306/04	Mana 90/01	E	BC	cc
2006 SI	389	820/04	Mana 90/01	E	CC	aa
2006 SI	390	820/04	Mana 90/01	E	CC	aa
2006 SI	462	419/04	Mana 90/01	E	AC	ab
2006 SI	499	118/04	Mana 90/01	R	BC	aa
2006 SI	546	440/04	Mana 90/01	R	CC	ac
2006 SI	547	440/04	Mana 90/01	E	CC	ac
2006 SI	617	339/04	Mana 90/01	E	BC	aa
2006 SI	618	339/04	Mana 90/01	E	CC	ac
2006 SI	644	129/04	Mana 90/01	E	CC	ac
2006 SI	703	584/04	Mana 90/01	R	BC	aa
2006 SI	704	584/04	Mana 90/01	E	CC	ac
2006 SI	720	92/04	Mana 90/01	E	BC	aa
2006 SI	751	527/04	Mana 90/01	E	CC	ac
2006 SI	757	590/04	Mana 90/01	E	BC	aa
2006 SI	760	399/04	Mana 90/01	R	BC	aa
2006 SI	761	399/04	Mana 90/01	R	BC	aa
2006 SI	933	120/04	Mana 90/01	E	BC	aa
2006 SI	1016	672/04	Mana 90/01	E	BC	aa
2006 SI	1052	465/04	Mana 90/01	E	CC	cc
2006 SI	1087	449/04	Mana 90/01	E	BC	aa
2006 SI	1140	850/04	Mana 90/01	E	CC	ac
2006 SI	1141	850/04	Mana 90/01	E	CC	cc
2006 SI	1148	578/04	Mana 90/01	R	CC	cc
2006 SI	1245	434/04	Mana 90/01	R	BC	aa
2006 SI	1291	650/04	Mana 90/01	E	BC	aa
2006 SI	3129	177/04	Mana 90/01	R	CC	ac
2006 SI	3134	246/04	Mana 90/01	E	BC	ac
2006 SI	3135	58/04	Mana 90/01	R	BC	aa
2006 SI	3157	612/04	Mana 90/01	R	CC	ab
2006 SI	3158	612/04	Mana 90/01	E	CC	ac

2006 SI	3159	612/04	Mana 90/01	R	CC	ac
2006 SI	23	173/04	Mana 83/04	R	BB	aa
2006 SI	25	728/04	Mana 83/04	R	BC	aa
2006 SI	63	685/04	Mana 83/04	E	BB	aa
2006 SI	102	429/04	Mana 83/04	R	BB	ac
2006 SI	126	227/04	Mana 83/04	E	BB	aa
2006 SI	149	669/04	Mana 83/04	R	BC	cc
2006 SI	351	722/04	Mana 83/04	R	BB	aa
2006 SI	391	545/04	Mana 83/04	E	BB	aa
2006 SI	392	545/04	Mana 83/04	E	BB	aa
2006 SI	397	468/04	Mana 83/04	E	BB	aa
2006 SI	410	455/04	Mana 83/04	E	BC	aa
2006 SI	445	370/04	Mana 83/04	E	CC	cc
2006 SI	528	651/04	Mana 83/04	E	BB	aa
2006 SI	600	573/04	Mana 83/04	E	BC	aa
2006 SI	674	786/04	Mana 83/04	E	CC	cc
2006 SI	745	372/04	Mana 83/04	R	CC	ac
2006 SI	752	304/04	Mana 83/04	E	BB	aa
2006 SI	817	577/04	Mana 83/04	E	CC	ac
2006 SI	818	577/04	Mana 83/04	R	BC	aa
2006 SI	831	319/04	Mana 83/04	R	CC	cc
2006 SI	864	562/04	Mana 83/04	E	BB	aa
2006 SI	869	600/04	Mana 83/04	R	BB	aa
2006 SI	870	600/04	Mana 83/04	E	BB	aa
2006 SI	915	795/04	Mana 83/04	E	BB	aa
2006 SI	924	31 /04	Mana 83/04	E	CC	cc
2006 SI	946	469/04	Mana 83/04	R	BB	bc
2006 SI	947	469/04	Mana 83/04	E	BB	aa
2006 SI	1103	441/04	Mana 83/04	R	AC	bb
2006 SI	3126	93/04	Mana 83/04	E	CC	ac
2006 SI	144	463/04	Longridge 626/02	R	BB	aa
2006 SI	213	522/04	Longridge 626/02	R	BB	aa
2006 SI	233	608/04	Longridge 626/02	E	BB	ab
2006 SI	371	471/04	Longridge 626/02	E	BB	aa
2006 SI	661	404/04	Longridge 626/02	E	AC	bc
2006 SI	662	845/04	Longridge 626/02	R	AC	bc
2006 SI	838	480/04	Longridge 626/02	E	AC	bc
2006 SI	850	583/04	Longridge 626/02	R	AC	bc
2006 SI	1038	236/04	Longridge 626/02	E	BB	aa
2006 SI	1046	621/04	Longridge 626/02	R	AC	bc
2006 SI	289	224/04	Leeds Lodge 26/03	R	CC	ac
2006 SI	296	560/04	Leeds Lodge 26/03	R	BC	ac
2006 SI	421	286/04	Leeds Lodge 26/03	R	AC	ab
2006 SI	485	707/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	486	707/04	Leeds Lodge 26/03	E	BC	aa

2006 SI	567	34/04	Leeds Lodge 26/03	E	CC	aa
2006 SI	582	530/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	583	530/04	Leeds Lodge 26/03	E	BC	aa
2006 SI	609	379/04	Leeds Lodge 26/03	R	AC	ab
2006 SI	610	379/04	Leeds Lodge 26/03	E	AC	ab
2006 SI	738	759/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	769	495/04	Leeds Lodge 26/03	R	CC	aa
2006 SI	770	495/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	810	203/04	Leeds Lodge 26/03	E	CC	ac
2006 SI	848	700/04	Leeds Lodge 26/03	R	CC	aa
2006 SI	875	466/04	Leeds Lodge 26/03	E	CC	ac
2006 SI	876	466/04	Leeds Lodge 26/03	E	CC	ac
2006 SI	950	331/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	994	343/04	Leeds Lodge 26/03	E	AC	ab
2006 SI	1001	336/04	Leeds Lodge 26/03	E	BC	aa
2006 SI	1007	486/04	Leeds Lodge 26/03	R	BB	ab
2006 SI	1020	700/04	Leeds Lodge 26/03	E	BC	aa
2006 SI	1023	109/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	1048	833/04	Leeds Lodge 26/03	E	AC	ab
2006 SI	1082	494/04	Leeds Lodge 26/03	E	BC	aa
2006 SI	1084	642/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	1085	642/04	Leeds Lodge 26/03	E	CC	ac
2006 SI	1150	563/04	Leeds Lodge 26/03	R	CC	ac
2006 SI	1183	571/04	Leeds Lodge 26/03	R	CC	ac
2006 SI	1184	571/04	Leeds Lodge 26/03	R	CC	aa
2006 SI	1191	556/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	1192	556/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	1225	490/04	Leeds Lodge 26/03	R	CC	aa
2006 SI	1239	576/04	Leeds Lodge 26/03	E	BC	aa
2006 SI	1249	382/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	3138	22 /04	Leeds Lodge 26/03	R	BC	aa
2006 SI	3143	201/04	Leeds Lodge 26/03	R	BC	aa
2006 SI	3145	247/04	Leeds Lodge 26/03	E	CC	aa
2006 SI	3149	529/04	Leeds Lodge 26/03	E	BC	aa
2006 SI	3150	551/04	Leeds Lodge 26/03	R	AC	ab
2006 SI+389:493	43	400/04	Hermiston 22/04	R	CC	ac
2006 SI	44	400/04	Hermiston 22/04	E	BC	bc
2006 SI	49	133/04	Hermiston 22/04	E	CC	cc
2006 SI	154	473/04	Hermiston 22/04	R	BC	ac
2006 SI	155	473/04	Hermiston 22/04	E	CC	cc
2006 SI	290	200/04	Hermiston 22/04	R	CC	ab
2006 SI	294	96/04	Hermiston 22/04	R	BC	ab
2006 SI	304	733/04	Hermiston 22/04	E	AC	bc
2006 SI	361	284/04	Hermiston 22/04	R	BC	bc
2006 SI	468	509/04	Hermiston 22/04	E	BC	aa

2006 SI	487	334/04	Hermiston 22/04	R	BC	aa
2006 SI	542	566/04	Hermiston 22/04	E	BC	aa
2006 SI	549	406/04	Hermiston 22/04	R	CC	ac
2006 SI	585	575/04	Hermiston 22/04	E	CC	ac
2006 SI	586	575/04	Hermiston 22/04	E	CC	ac
2006 SI	611	326/04	Hermiston 22/04	R	BC	aa
2006 SI	612	326/04	Hermiston 22/04	E	BC	aa
2006 SI	614	841/04	Hermiston 22/04	E	BC	cc
2006 SI	630	649/04	Hermiston 22/04	R	CC	aa
2006 SI	631	649/04	Hermiston 22/04	R	CC	aa
2006 SI	716	217/04	Hermiston 22/04	R	CC	cc
2006 SI	724	170/04	Hermiston 22/04	R	CC	ab
2006 SI	766	683/04	Hermiston 22/04	R	BC	ab
2006 SI	805	271/04	Hermiston 22/04	R	CC	cc
2006 SI	841	716/04	Hermiston 22/04	R	AC	bc
2006 SI	842	716/04	Hermiston 22/04	R	AC	bc
2006 SI	860	446/04	Hermiston 22/04	R	CC	ab
2006 SI	861	446/04	Hermiston 22/04	E	BC	aa
2006 SI	873	605/04	Hermiston 22/04	E	CC	ac
2006 SI	874	605/04	Hermiston 22/04	E	BC	aa
2006 SI	908	368/04	Hermiston 22/04	E	CC	cc
2006 SI	927	21 /04	Hermiston 22/04	R	CC	aa
2006 SI	935	91/04	Hermiston 22/04	E	CC	ac
2006 SI	974	829/04	Hermiston 22/04	E	BC	ab
2006 SI	983	564/04	Hermiston 22/04	R	BC	ab
2006 SI	984	564/04	Hermiston 22/04	E	BC	aa
2006 SI	988	324/04	Hermiston 22/04	E	CC	cc
2006 SI	1031	157/04	Hermiston 22/04	R	AC	bc
2006 SI	1077	713/04	Hermiston 22/04	E	BC	aa
2006 SI	1088	798/04	Hermiston 22/04	E	CC	aa
2006 SI	1105	313/04	Hermiston 22/04	R	AC	bc
2006 SI	1122	496/04	Hermiston 22/04	R	AC	ab
2006 SI	1123	761/04	Hermiston 22/04	E	BC	aa
2006 SI	1165	589/04	Hermiston 22/04	R	BC	aa
2006 SI	1174	561/04	Hermiston 22/04	E	CC	ac
2006 SI	1175	561/04	Hermiston 22/04	R	BC	aa
2006 SI	1197	340/04	Hermiston 22/04	E	BC	aa
2006 SI	1213	258/04	Hermiston 22/04	R	AC	ab
2006 SI	1217	373/04	Hermiston 22/04	R	AC	bc
2006 SI	1218	373/04	Hermiston 22/04	R	AC	ab
2006 SI	1220	373/04	Hermiston 22/04	E	AC	ab
2006 SI	1251	652/04	Hermiston 22/04	R	CC	ac
2006 SI	1262	143/04	Hermiston 22/04	E	BC	aa
2006 SI	1274	581/04	Hermiston 22/04	R	CC	ab
2006 SI	1275	581/04	Hermiston 22/04	E	CC	ac

2006 SI	1279	491/04	Hermiston 22/04	E	CC	ac
2006 SI	3167	512/04	Hermiston 22/04	R	BC	aa
2006 SI	3168	512/04	Hermiston 22/04	R	BC	aa
2006 SI	3182	97/04	Hermiston 22/04	R	CC	ac
2006 SI	3199	513/04	Hermiston 22/04	R	CC	cc
2006 SI	3200	513/04	Hermiston 22/04	E	CC	cc
2006 SI	150	310/04	Glenleith 252/04	R	BC	aa
2006 SI	171	55/04	Glenleith 252/04	R	AA	bb
2006 SI	243	813/04	Glenleith 252/04	R	BC	aa
2006 SI	244	813/04	Glenleith 252/04	R	BC	aa
2006 SI	266	53/04	Glenleith 252/04	R	BC	aa
2006 SI	270	826/04	Glenleith 252/04	R	CC	ac
2006 SI	271	826/04	Glenleith 252/04	E	CC	ac
2006 SI	354	482/04	Glenleith 252/04	E	BC	aa
2006 SI	362	152/04	Glenleith 252/04	E	BC	aa
2006 SI	408	459/04	Glenleith 252/04	E	CC	ac
2006 SI	498	104/04	Glenleith 252/04	R	AA	bb
2006 SI	507	314/04	Glenleith 252/04	E	CC	aa
2006 SI	526	664/04	Glenleith 252/04	R	BC	aa
2006 SI	527	664/04	Glenleith 252/04	R	CC	ac
2006 SI	708	511/04	Glenleith 252/04	E	CC	ac
2006 SI	742	787/04	Glenleith 252/04	R	CC	ac
2006 SI	743	787/04	Glenleith 252/04	R	CC	ac
2006 SI	824	620/04	Glenleith 252/04	R	BC	aa
2006 SI	834	640/04	Glenleith 252/04	E	BB	ab
2006 SI	862	333/04	Glenleith 252/04	R	AA	bb
2006 SI	918	1 /04	Glenleith 252/04	E	BC	aa
2006 SI	1154	721/04	Glenleith 252/04	E	BC	aa
2006 SI	3133	128/04	Glenleith 252/04	E	AA	bb
2006 SI	3142	140/04	Glenleith 252/04	E	AC	bb
2006 SI	3170	604/04	Glenleith 252/04	E	AA	bb
200+243:2616 SI	22	278/04	Glenleith 25/02	E	BC	aa
2006 SI	34	622/04	Glenleith 25/02	E	BB	aa
2006 SI	62	637/04	Glenleith 25/02	E	BB	aa
2006 SI	201	43/04	Glenleith 25/02	E	BB	aa
2006 SI	234	593/04	Glenleith 25/02	R	CC	ac
2006 SI	265	241/04	Glenleith 25/02	E	CC	ac
2006 SI	307	415/04	Glenleith 25/02	E	BB	aa
2006 SI	313	78/04	Glenleith 25/02	E	BB	aa
2006 SI	383	501/04	Glenleith 25/02	E	BC	cc
2006 SI	447	655/04	Glenleith 25/02	R	CC	cc
2006 SI	448	655/04	Glenleith 25/02	E	CC	cc
2006 SI	475	489/04	Glenleith 25/02	R	BB	aa
2006 SI	476	489/04	Glenleith 25/02	E	BC	aa
2006 SI	513	396/04	Glenleith 25/02	R	CC	bc

2006 SI	619	699/04	Glenleith 25/02	R	BC	aa
2006 SI	620	699/04	Glenleith 25/02	R	BC	aa
2006 SI	637	855/04	Glenleith 25/02	R	BB	aa
2006 SI	638	855/04	Glenleith 25/02	R	BC	cc
2006 SI	648	629/04	Glenleith 25/02	R	CC	cc
2006 SI	649	629/04	Glenleith 25/02	E	BC	cc
2006 SI	679	840/04	Glenleith 25/02	E	BC	aa
2006 SI	697	360/04	Glenleith 25/02	R	CC	ac
2006 SI	698	360/04	Glenleith 25/02	E	CC	ac
2006 SI	723	127/04	Glenleith 25/02	R	BC	aa
2006 SI	872	356/04	Glenleith 25/02	E	CC	cc
2006 SI	925	134/04	Glenleith 25/02	E	BB	aa
2006 SI	1203	20 /04	Glenleith 25/02	R	CC	cc
2006 SI	1209	208/04	Glenleith 25/02	R	CC	bc
2006 SI	1280	676/04	Glenleith 25/02	R	AC	bb
2006 SI	3160	856/04	Glenleith 25/02	R	BB	aa
2006 SI	3161	856/04	Glenleith 25/02	R	BB	aa
2006 SI	12	131/04	Doughboy 45/04	R	BC	bc
2006 SI	17	818/04	Doughboy 45/04	R	BC	ac
2006 SI	18	818/04	Doughboy 45/04	R	BC	ac
2006 SI	21	29 /04	Doughboy 45/04	E	BC	ac
2006 SI	70	689/04	Doughboy 45/04	E	AC	bc
2006 SI	71	689/04	Doughboy 45/04	E	AC	bc
2006 SI	77	79/04	Doughboy 45/04	E	BC	ac
2006 SI	110	715/04	Doughboy 45/04	R	CC	ac
2006 SI	111	715/04	Doughboy 45/04	E	BC	ac
2006 SI	120	837/04	Doughboy 45/04	R	BC	ac
2006 SI	121	837/04	Doughboy 45/04	R	BC	ac
2006 SI	195	763/04	Doughboy 45/04	R	AC	bc
2006 SI	203	230/04	Doughboy 45/04	R	CC	cc
2006 SI	256	731/04	Doughboy 45/04	E	BC	ac
2006 SI	298	472/04	Doughboy 45/04	R	BC	bc
2006 SI	387	363/04	Doughboy 45/04	R	BC	ac
2006 SI	388	363/04	Doughboy 45/04	E	BC	ac
2006 SI	417	106/04	Doughboy 45/04	E	CC	ac
2006 SI	423	28 /04	Doughboy 45/04	R	CC	cc
2006 SI	463	323/04	Doughboy 45/04	R	BC	ac
2006 SI	464	323/04	Doughboy 45/04	E	BC	ac
2006 SI	494	401/04	Doughboy 45/04	R	BC	ac
2006 SI	495	401/04	Doughboy 45/04	R	BC	ac
2006 SI	522	180/04	Doughboy 45/04	R	BC	ac
2006 SI	523	180/04	Doughboy 45/04	E	BC	ac
2006 SI	532	810/04	Doughboy 45/04	R	BC	ac
2006 SI	533	810/04	Doughboy 45/04	E	CC	cc
2006 SI	577	11 /04	Doughboy 45/04	R	CC	cc

2006 SI	578	11 /04	Doughboy 45/04	E	CC	cc
2006 SI	701	302/04	Doughboy 45/04	R	BC	ac
2006 SI	702	302/04	Doughboy 45/04	E	BC	ac
2006 SI	746	751/04	Doughboy 45/04	R	BC	ac
2006 SI	747	751/04	Doughboy 45/04	R	BC	ac
2006 SI	809	179/04	Doughboy 45/04	E	CC	ac
2006 SI	811	139/04	Doughboy 45/04	R	BC	ac
2006 SI	819	710/04	Doughboy 45/04	R	BC	ac
2006 SI	820	710/04	Doughboy 45/04	E	CC	cc
2006 SI	913	653/04	Doughboy 45/04	E	CC	cc
2006 SI	930	164/04	Doughboy 45/04	E	AC	bc
2006 SI	938	7 /04	Doughboy 45/04	R	CC	ac
2006 SI	995	477/04	Doughboy 45/04	R	AC	bc
2006 SI	996	477/04	Doughboy 45/04	E	AC	bc
2006 SI	1022	168/04	Doughboy 45/04	E	AC	bc
2006 SI	1030	130/04	Doughboy 45/04	E	BC	ac
2006 SI	1041	445/04	Doughboy 45/04	E	BC	ac
2006 SI	1066	329/04	Doughboy 45/04	R	CC	ac
2006 SI	1067	329/04	Doughboy 45/04	R	BC	ac
2006 SI	1079	692/04	Doughboy 45/04	R	BC	ac
2006 SI	1080	692/04	Doughboy 45/04	E	BC	ac
2006 SI	1081	692/04	Doughboy 45/04	E	BC	ac
2006 SI	1115	417/04	Doughboy 45/04	E	BC	ac
2006 SI	1127	748/04	Doughboy 45/04	R	CC	cc
2006 SI	1128	748/04	Doughboy 45/04	R	CC	cc
2006 SI	1132	592/04	Doughboy 45/04	R	CC	cc
2006 SI	1133	592/04	Doughboy 45/04	E	CC	bc
2006 SI	1159	479/04	Doughboy 45/04	R	BC	ac
2006 SI	1180	418/04	Doughboy 45/04	E	BC	ac
2006 SI	1215	73/04	Doughboy 45/04	E	BC	ac
2006 SI	1241	568/04	Doughboy 45/04	R	CC	bc
2006 SI	1258	2 /04	Doughboy 45/04	R	AC	bc
2006 SI	1260	281/04	Doughboy 45/04	R	CC	ac
2006 SI	1272	337/04	Doughboy 45/04	R	BC	aa
2006 SI	1273	337/04	Doughboy 45/04	R	BC	ac
2006 SI	3185	196/04	Doughboy 45/04	R	BC	ac
2006 SI	3191	308/04	Doughboy 45/04	E	CC	cc
2006 SI	7	346/04	Braebank 67/03	R	BC	aa
2006 SI	31	658/04	Braebank 67/03	R	BC	aa
2006 SI	32	658/04	Braebank 67/03	E	BC	aa
2006 SI	50	283/04	Braebank 67/03	R	CC	aa
2006 SI	80	553/04	Braebank 67/03	R	BC	aa
2006 SI	81	553/04	Braebank 67/03	E	BC	aa
2006 SI	104	827/04	Braebank 67/03	R	BC	aa
2006 SI	226	755/04	Braebank 67/03	E	CC	ac

2006 SI	254	351/04	Braebank 67/03	R	CC	aa
2006 SI	255	351/04	Braebank 67/03	E	CC	aa
2006 SI	274	410/04	Braebank 67/03	E	CC	ac
2006 SI	275	410/04	Braebank 67/03	E	BC	aa
2006 SI	328	347/04	Braebank 67/03	R	BC	aa
2006 SI	329	347/04	Braebank 67/03	E	BC	aa
2006 SI	336	519/04	Braebank 67/03	E	BC	aa
2006 SI	337	519/04	Braebank 67/03	E	CC	aa
2006 SI	349	411/04	Braebank 67/03	E	CC	ac
2006 SI	430	403/04	Braebank 67/03	E	BC	aa
2006 SI	536	390/04	Braebank 67/03	R	BC	aa
2006 SI	545	431/04	Braebank 67/03	E	CC	ac
2006 SI	571	260/04	Braebank 67/03	R	BC	aa
2006 SI	576	191/04	Braebank 67/03	E	BC	aa
2006 SI	624	817/04	Braebank 67/03	R	BC	aa
2006 SI	634	506/04	Braebank 67/03	E	CC	ac
2006 SI	671	687/04	Braebank 67/03	R	BC	aa
2006 SI	693	452/04	Braebank 67/03	R	CC	aa
2006 SI	694	452/04	Braebank 67/03	E	CC	ac
2006 SI	700	292/04	Braebank 67/03	E	BC	aa
2006 SI	804	213/04	Braebank 67/03	E	CC	ac
2006 SI	847	397/04	Braebank 67/03	E	BC	aa
2006 SI	923	147/04	Braebank 67/03	E	BC	aa
2006 SI	952	609/04	Braebank 67/03	E	BC	ac
2006 SI	953	609/04	Braebank 67/03	E	BC	ac
2006 SI	3162	467/04	Braebank 67/03	R	BC	aa
2006 SI	3184	198/04	Braebank 67/03	E	BC	aa
2006 SI	57	366/04	Banklea 217/00	E	BC	ac
2006 SI	125	59/04	Banklea 217/00	E	BB	aa
2006 SI	161	772/04	Banklea 217/00	R	AA	bb
2006 SI	166	613/04	Banklea 217/00	E	AA	bb
2006 SI	167	613/04	Banklea 217/00	E	BC	aa
2006 SI	216	108/04	Banklea 217/00	E	BB	aa
2006 SI	426	193/04	Banklea 217/00	R	AA	bb
2006 SI	443	791/04	Banklea 217/00	E	BB	aa
2006 SI	444	791/04	Banklea 217/00	E	AA	bb
2006 SI	469	773/04	Banklea 217/00	E	AC	bb
2006 SI	641	24 /04	Banklea 217/00	E	BB	ab
2006 SI	718	115/04	Banklea 217/00	E	BC	aa
2006 SI	857	475/04	Banklea 217/00	E	BB	aa
2006 SI	921	54/04	Banklea 217/00	E	BB	aa
2006 SI	1008	767/04	Banklea 217/00	R	BC	aa
2006 SI	1062	749/04	Banklea 217/00	R	BB	aa
2006 SI	1112	779/04	Banklea 217/00	R	AC	bb
2006 SI	1162	293/04	Banklea 217/00	E	BC	aa

2006 SI	1250	737/04	Banklea 217/00	E	AA	bb
2006 SI	859	858/04		E	BB	aa
2006 SI	1134				BC	aa
2006 SI	1135			E	BC	aa
2006 SI	1210				CC	ac
2006 SI	1214				BC	aa
2006 SI	1221				BB	aa
2006 SI	48	204/04	Waidale 618/04	R	AA	ab
2006 SI	69	847/04	Waidale 618/04	E	AA	ab
2006 SI	86	701/04	Waidale 618/04	E	AA	ab
2006 SI	98	756/04	Waidale 618/04	R	AA	ab
2006 SI	198	681/04	Waidale 618/04	E	AA	ab
2006 SI	276	752/04	Waidale 618/04	R	AB	ab
2006 SI	342	647/04	Waidale 618/04	E	AA	ab
2006 SI	343	647/04	Waidale 618/04	E	AA	ab
2006 SI	517	788/04	Waidale 618/04	E	AA	ab
2006 SI	518	788/04	Waidale 618/04	E	AA	ab
2006 SI	794	857/04	Waidale 618/04	R	AA	ab
2006 SI	795	857/04	Waidale 618/04	R	AA	ab
2006 SI	816	182/04	Waidale 618/04	E	AA	ab
2006 SI	106	536/04	Totaranui 376/02	E	AB	aa
2006 SI	146	330/04	Totaranui 376/02	R	AB	aa
2006 SI	320	554/04	Totaranui 376/02	E	AA	ab
2006 SI	375	499/04	Totaranui 376/02	E	AB	aa
2006 SI	496	18 /04	Totaranui 376/02	E	AB	aa
2006 SI	588	570/04	Totaranui 376/02	R	AA	ab
2006 SI	592	312/04	Totaranui 376/02	E	AB	aa
2006 SI	815	86/04	Totaranui 376/02	R	AA	ab
2006 SI	853	352/04	Totaranui 376/02	R	AB	aa
2006 SI	1021	287/04	Totaranui 376/02	E	AA	ab
2006 SI	1059	549/04	Totaranui 376/02	E	AB	aa
2006 SI+1118:1188	8	611/04	Tanlet 547/02	E	AA	ab
2006 SI	9	611/04	Tanlet 547/02	R	AC	ac
2006 SI	47	195/04	Tanlet 547/02	E	AA	aa
2006 SI	310	238/04	Tanlet 547/02	E	AB	aa
2006 SI	345	567/04	Tanlet 547/02	E	AC	ac
2006 SI	378	67/04	Tanlet 547/02	E	AC	aa
2006 SI	415	317/04	Tanlet 547/02	R	AC	ac
2006 SI	663	811/04	Tanlet 547/02	E	AB	aa
2006 SI	695	709/04	Tanlet 547/02	R	AC	ac
2006 SI	890	729/04	Tanlet 547/02	R	AA	ab
2006 SI	1004	648/04	Tanlet 547/02	R	AB	aa
2006 SI	1005	648/04	Tanlet 547/02	R	AB	aa
2006 SI	1036	51/04	Tanlet 547/02	E	AB	aa

2006 SI	1076	315/04	Tanlet 547/02	R	AB	aa
2006 SI	1177	444/04	Tanlet 547/02	R	AB	aa
2006 SI	1179	444/04	Tanlet 547/02	R	AB	aa
2006 SI	1229	792/04	Tanlet 547/02	E	AC	ab
2006 SI	1235	758/04	Tanlet 547/02	E	AB	aa
2006 SI	3156	359/04	Tanlet 547/02	R	AA	aa
2006 SI	89	44/04	Sudeley 102/04	E	AC	aa
2006 SI	200	110/04	Sudeley 102/04	R	AB	aa
2006 SI	425	137/04	Sudeley 102/04	E	AB	aa
2006 SI	515	532/04	Sudeley 102/04	R	AB	aa
2006 SI	944	776/04	Sudeley 102/04	E	AB	aa
2006 SI	45	107/04	Snowlea 192/02	E	AB	aa
2006 SI	152	393/04	Snowlea 192/02	R	AB	aa
2006 SI	366	89/04	Snowlea 192/02	E	AB	aa
2006 SI	480	762/04	Snowlea 192/02	E	AB	aa
2006 SI	807	72/04	Snowlea 192/02	R	AB	aa
2006 SI	963	631/04	Snowlea 192/02	R	AB	aa
2006 SI	1246	750/04	Snowlea 192/02	R	AB	aa
2006 SI	187	741/04	Offord 414/01	R	AB	aa
2006 SI	246	493/04	Offord 414/01	R	AB	aa
2006 SI	280	595/04	Offord 414/01	E	AB	aa
2006 SI	315	318/04	Offord 414/01	R	AC	aa
2006 SI	437	533/04	Offord 414/01	R	AC	aa
2006 SI	584	587/04	Offord 414/01	R	AB	aa
2006 SI	596	291/04	Offord 414/01	E	AB	aa
2006 SI	597	291/04	Offord 414/01	E	AB	aa
2006 SI	670	668/04	Offord 414/01	R	AC	aa
2006 SI	845	405/04	Offord 414/01	R	AC	aa
2006 SI	1207	207/04	Offord 414/01	R	AC	aa
2006 SI	3139	60/04	Offord 414/01	R	AC	aa
2006 SI	88	783/04	Mana 90/01	R	AC	aa
2006 SI	428	594/04	Mana 90/01	R	AC	aa
2006 SI	461	419/04	Mana 90/01	R	AC	aa
2006 SI	501	146/04	Mana 90/01	E	AC	aa
2006 SI	1073	295/04	Mana 90/01	E	AC	aa
2006 SI	1149	578/04	Mana 90/01	E	AC	aa
2006 SI	1195	691/04	Mana 90/01	E	AC	aa
2006 SI	814	231/04	Mana 83/04	E	AB	aa
2006 SI	1	414/04	Longridge 626/02	R	AB	aa
2006 SI	72	558/04	Longridge 626/02	R	AA	aa
2006 SI	73	558/04	Longridge 626/02	E	AA	aa
2006 SI	84	518/04	Longridge 626/02	E	AB	aa
2006 SI	145	463/04	Longridge 626/02	R	AC	ac
2006 SI	168	540/04	Longridge 626/02	E	AA	ab
2006 SI	169	540/04	Longridge 626/02	E	AC	aa

2006 SI	208	464/04	Longridge 626/02	R	AC	ac
2006 SI	212	522/04	Longridge 626/02	R	AC	ac
2006 SI	218	112/04	Longridge 626/02	E	AC	aa
2006 SI	232	608/04	Longridge 626/02	R	AB	aa
2006 SI	278	299/04	Longridge 626/02	E	AB	ac
2006 SI	279	299/04	Longridge 626/02	E	AB	ac
2006 SI	327	764/04	Longridge 626/02	E	AC	ac
2006 SI	372	606/04	Longridge 626/02	R	AC	ac
2006 SI	373	606/04	Longridge 626/02	E	AC	ac
2006 SI	483	303/04	Longridge 626/02	R	AC	aa
2006 SI	484	303/04	Longridge 626/02	E	AB	aa
2006 SI	492	781/04	Longridge 626/02	R	AA	aa
2006 SI	493	781/04	Longridge 626/02	E	AA	ab
2006 SI	497	188/04	Longridge 626/02	E	AB	aa
2006 SI	775	267/04	Longridge 626/02	R	AA	ab
2006 SI	776	267/04	Longridge 626/02	R	AA	ab
2006 SI	830	625/04	Longridge 626/02	E	AC	aa
2006 SI	835	480/04	Longridge 626/02	R	AC	aa
2006 SI	837	480/04	Longridge 626/02	R	AC	aa
2006 SI	851	583/04	Longridge 626/02	E	AC	ac
2006 SI	971	358/04	Longridge 626/02	E	AB	ac
2006 SI	972	358/04	Longridge 626/02	E	AB	ac
2006 SI	981	362/04	Longridge 626/02	R	AC	aa
2006 SI	982	362/04	Longridge 626/02	E	AC	ac
2006 SI	1013	387/04	Longridge 626/02	R	AA	aa
2006 SI	1014	387/04	Longridge 626/02	R	AA	aa
2006 SI	1039	216/04	Longridge 626/02	E	AA	ab
2006 SI	1099	301/04	Longridge 626/02	R	AA	ab
2006 SI	1116	794/04	Longridge 626/02	R	AA	ab
2006 SI	1129	478/04	Longridge 626/02	E	AB	aa
2006 SI	1204	66/04	Longridge 626/02	R	AA	aa
2006 SI	1233	662/04	Longridge 626/02	R	AC	ac
2006 SI	3164	391/04	Longridge 626/02	R	AB	aa
2006 SI+565:636	202	84/04	Leeds Lodge 26/03	E	AC	aa
2006 SI	385	667/04	Leeds Lodge 26/03	R	AC	aa
2006 SI	386	667/04	Leeds Lodge 26/03	E	AC	aa
2006 SI	787	603/04	Leeds Lodge 26/03	E	AC	aa
2006 SI	1000	336/04	Leeds Lodge 26/03	R	AC	aa
2006 SI	1125	538/04	Leeds Lodge 26/03	R	AC	aa
2006 SI	15	539/04	Lammerlaw 77/04	R	AA	ab
2006 SI	16	539/04	Lammerlaw 77/04	R	AA	ab
2006 SI	39	432/04	Lammerlaw 77/04	R	AB	aa
2006 SI	40	432/04	Lammerlaw 77/04	E	AB	aa
2006 SI	55	760/04	Lammerlaw 77/04	E	AB	aa
2006 SI	56	760/04	Lammerlaw 77/04	E	AB	aa

2006 SI	74	273/04	Lammerlaw 77/04	E	AC	aa
2006 SI	92	555/04	Lammerlaw 77/04	E	AA	aa
2006 SI	93	555/04	Lammerlaw 77/04	E	AA	aa
2006 SI	114	26 /04	Lammerlaw 77/04	R	AB	aa
2006 SI	116	485/04	Lammerlaw 77/04	R	AA	ab
2006 SI	138	802/04	Lammerlaw 77/04	R	AB	ab
2006 SI	139	802/04	Lammerlaw 77/04	E	AB	ab
2006 SI	231	656/04	Lammerlaw 77/04	E	AC	aa
2006 SI	236	187/04	Lammerlaw 77/04	E	AB	aa
2006 SI	284	726/04	Lammerlaw 77/04	R	AC	ab
2006 SI	309	63/04	Lammerlaw 77/04	R	AA	ab
2006 SI	439	835/04	Lammerlaw 77/04	R	AA	ab
2006 SI	440	835/04	Lammerlaw 77/04	E	AB	ac
2006 SI	455	398/04	Lammerlaw 77/04	R	AC	ac
2006 SI	456	398/04	Lammerlaw 77/04	R	AB	aa
2006 SI	457	500/04	Lammerlaw 77/04	R	AC	ac
2006 SI	458	500/04	Lammerlaw 77/04	E	AC	ac
2006 SI	503	166/04	Lammerlaw 77/04	E	AB	aa
2006 SI	559	544/04	Lammerlaw 77/04	R	AB	aa
2006 SI	560	544/04	Lammerlaw 77/04	E	AB	aa
2006 SI	570	121/04	Lammerlaw 77/04	R	AA	aa
2006 SI	590	586/04	Lammerlaw 77/04	R	AC	aa
2006 SI	594	804/04	Lammerlaw 77/04	R	AB	aa
2006 SI	595	804/04	Lammerlaw 77/04	E	AC	ac
2006 SI	605	262/04	Lammerlaw 77/04	R	AC	aa
2006 SI	606	262/04	Lammerlaw 77/04	E	AC	aa
2006 SI	658	311/04	Lammerlaw 77/04	E	AB	ab
2006 SI	659	311/04	Lammerlaw 77/04	E	AC	aa
2006 SI	806	242/04	Lammerlaw 77/04	E	AB	aa
2006 SI	839	644/04	Lammerlaw 77/04	R	AA	ab
2006 SI	893	543/04	Lammerlaw 77/04	E	AA	aa
2006 SI	894	543/04	Lammerlaw 77/04	E	AA	aa
2006 SI	898	703/04	Lammerlaw 77/04	E	AB	aa
2006 SI	1024	17 /04	Lammerlaw 77/04	R	AB	aa
2006 SI	1026	117/04	Lammerlaw 77/04	R	AB	aa
2006 SI	1035	172/04	Lammerlaw 77/04	E	AB	aa
2006 SI	1164	598/04	Lammerlaw 77/04	E	AB	aa
2006 SI	1201	277/04	Lammerlaw 77/04	R	AC	ac
2006 SI	1202	277/04	Lammerlaw 77/04	R	AB	aa
2006 SI	3127	23 /04	Lammerlaw 77/04	E	AB	aa
2006 SI	3141	155/04	Lammerlaw 77/04	E	AB	aa
2006 SI	3144	65/04	Lammerlaw 77/04	R	AB	aa
2006 SI	3172	451/04	Lammerlaw 77/04	E	AC	ac
2006 SI	3181	178/04	Lammerlaw 77/04	E	AB	aa
2006 SI	488	334/04	Hermiston 22/04	E	AC	aa

2006 SI	754	261/04	Hermiston 22/04	R	AC	aa
2006 SI	755	261/04	Hermiston 22/04	E	AC	aa
2006 SI	1187	322/04	Hermiston 22/04	R	AC	aa
2006 SI	1196	340/04	Hermiston 22/04	E	AC	aa
2006 SI	1265	239/04	Hermiston 22/04	R	AC	aa
2006 SI	51	765/04	Glenleith 252/04	E	AB	aa
2006 SI	52	765/04	Glenleith 252/04	R	AB	aa
2006 SI	317	661/04	Glenleith 252/04	R	AA	ab
2006 SI	318	661/04	Glenleith 252/04	E	AA	ab
2006 SI	656	438/04	Glenleith 252/04	R	AB	aa
2006 SI	778	442/04	Glenleith 252/04	R	AC	aa
2006 SI	833	640/04	Glenleith 252/04	E	AA	ab
2006 SI	849	505/04	Glenleith 252/04	R	AC	aa
2006 SI	1206	45/04	Glenleith 252/04	R	AB	aa
2006 SI	30	474/04	Glenleith 25/02	E	AB	aa
2006 SI	813	4 /04	Glenleith 25/02	E	AB	aa
2006 SI	928	80/04	Glenleith 25/02	E	AB	aa
2006 SI	1145	424/04	Glenleith 25/02	R	AB	aa
2006 SI	257	731/04	Doughboy 45/04	E	AC	ac
2006 SI	299	472/04	Doughboy 45/04	R	AC	ac
2006 SI	762	327/04	Doughboy 45/04	E	AC	ac
2006 SI	1040	445/04	Doughboy 45/04	R	AC	ac
2006 SI	20	114/04	Braebank 67/03	E	AB	aa
2006 SI	108	828/04	Braebank 67/03	R	AA	ab
2006 SI	109	828/04	Braebank 67/03	E	AA	ab
2006 SI	224	755/04	Braebank 67/03	E	AB	aa
2006 SI	259	328/04	Braebank 67/03	R	AB	aa
2006 SI	333	684/04	Braebank 67/03	E	AB	ac
2006 SI	340	630/04	Braebank 67/03	E	AB	aa
2006 SI	341	630/04	Braebank 67/03	E	AB	aa
2006 SI	420	52/04	Braebank 67/03	R	AC	aa
2006 SI	429	403/04	Braebank 67/03	R	AB	aa
2006 SI	500	122/04	Braebank 67/03	E	AB	ab
2006 SI	537	390/04	Braebank 67/03	R	AB	aa
2006 SI	621	300/04	Braebank 67/03	R	AA	aa
2006 SI	622	300/04	Braebank 67/03	R	AC	aa
2006 SI	672	687/04	Braebank 67/03	R	AA	ab
2006 SI	682	822/04	Braebank 67/03	R	AA	aa
2006 SI	683	822/04	Braebank 67/03	E	AA	aa
2006 SI	699	292/04	Braebank 67/03	E	AB	aa
2006 SI	885	591/04	Braebank 67/03	E	AB	aa
2006 SI	886	591/04	Braebank 67/03	E	AB	aa
2006 SI	887	711/04	Braebank 67/03	R	AA	aa
2006 SI	888	711/04	Braebank 67/03	R	AA	aa
2006 SI	939	744/04	Braebank 67/03	R	AB	aa

2006 SI	940	744/04	Braebank 67/03	E	AC	aa
2006 SI	1208	181/04	Braebank 67/03	E	AC	aa
2006 SI	1227	812/04	Braebank 67/03	R	AB	aa
2006 SI	3163	467/04	Braebank 67/03	E	AB	aa
2006 SI	3186	42/04	Braebank 67/03	E	AA	aa
2006 SI	300	335/04	Banklea 217/00	R	AC	aa
2006 SI	690	774/04	Banklea 217/00	R	AA	ab
2006 SI	748	307/04	Banklea 217/00	R	AA	ab
2006 SI	980	852/04	Banklea 217/00	E	AC	aa
2006 SI	1037	255/04	Banklea 217/00	E	AB	aa
2006 SI	1161	293/04	Banklea 217/00	R	AA	ab
2006 SI	3178	102/04	Banklea 217/00	E	AB	aa
2006 SI	858	858/04		R	AB	aa
2006 SI	725	211/04	Totaranui 376/02	R	AB	ab
2006 SI	277	752/04	Waidale 618/04	E	AB	ac
2006 SI	322	628/04	Waidale 618/04	R	BB	ab
2006 SI	360	221/04	Waidale 618/04	E	BC	bc
2006 SI	948	572/04	Waidale 618/04	R	BC	ab
2006 SI	949	572/04	Waidale 618/04	E	AC	ac
2006 SI	969	671/04	Waidale 618/04	R	AB	ac
2006 SI	970	671/04	Waidale 618/04	E	AB	ac
2006 SI	42	645/04	Totaranui 376/02	E	BC	ac
2006 SI	136	838/04	Totaranui 376/02	R	AB	ab
2006 SI	137	838/04	Totaranui 376/02	E	AB	ab
2006 SI	156	285/04	Totaranui 376/02	R	AB	ab
2006 SI	177	805/04	Totaranui 376/02	E	AB	ab
2006 SI	190	245/04	Totaranui 376/02	R	AB	ab
2006 SI	291	37/04	Totaranui 376/02	R	AB	ab
2006 SI	374	499/04	Totaranui 376/02	R	AC	ab
2006 SI	395	582/04	Totaranui 376/02	R	AC	bc
2006 SI	403	569/04	Totaranui 376/02	R	AC	bc
2006 SI	404	569/04	Totaranui 376/02	R	BC	ac
2006 SI	433	732/04	Totaranui 376/02	E	BC	ac
2006 SI	434	732/04	Totaranui 376/02	E	BC	ac
2006 SI	551	457/04	Totaranui 376/02	R	AB	ab
2006 SI	552	457/04	Totaranui 376/02	E	AB	ab
2006 SI	579	537/04	Totaranui 376/02	E	BC	ac
2006 SI	598	834/04	Totaranui 376/02	R	AC	ab
2006 SI	714	256/04	Totaranui 376/02	R	BC	ac
2006 SI	717	83/04	Totaranui 376/02	E	AC	bc
2006 SI	771	266/04	Totaranui 376/02	R	AB	ab
2006 SI	772	266/04	Totaranui 376/02	E	AB	ab
2006 SI	791	724/04	Totaranui 376/02	R	AC	bc
2006 SI	852	352/04	Totaranui 376/02	R	BC	ab
2006 SI	883	488/04	Totaranui 376/02	E	AB	ab

2006 SI	884	488/04	Totaranui 376/02	R	AC	bc
2006 SI	901	724/04	Totaranui 376/02	R	AB	ac
2006 SI	902	720/04	Totaranui 376/02	E	AB	ab
2006 SI	966	547/04	Totaranui 376/02	E	BC	ac
2006 SI	1058	549/04	Totaranui 376/02	E	AB	ab
2006 SI	1244	588/04	Totaranui 376/02	R	AC	bc
2006 SI	1282	534/04	Totaranui 376/02	R	AB	ab
2006 SI	3183	194/04	Totaranui 376/02	E	BC	ac
2006 SI	115	159/04	Tanlet 547/02	E	AB	ab
2006 SI	569	171/04	Tanlet 547/02	E	AB	ab
2006 SI	889	729/04	Tanlet 547/02	R	AB	ab
2006 SI	977	623/04	Tanlet 547/02	R	AB	ac
2006 SI	997	409/04	Tanlet 547/02	E	AB	ab
2006 SI	1025	252/04	Tanlet 547/02	R	AB	ab
2006 SI	1033	101/04	Tanlet 547/02	E	AB	ab
2006 SI	1045	433/04	Tanlet 547/02	E	AB	ab
2006 SI	13	448/04	Sudeley 102/04	R	BC	ac
2006 SI	14	448/04	Sudeley 102/04	R	BC	ac
2006 SI	26	263/04	Sudeley 102/04	R	BC	ac
2006 SI	94	447/04	Sudeley 102/04	E	BC	ac
2006 SI	96	695/04	Sudeley 102/04	E	AB	ab
2006 SI	97	695/04	Sudeley 102/04	E	AC	bc
2006 SI	182	483/04	Sudeley 102/04	R	AC	ac
2006 SI	193	525/04	Sudeley 102/04	E	BC	ac
2006 SI	220	3 /04	Sudeley 102/04	R	AC	bc
2006 SI	252	694/04	Sudeley 102/04	E	BC	ac
2006 SI	379	719/04	Sudeley 102/04	R	AC	ac
2006 SI	380	719/04	Sudeley 102/04	E	BC	ac
2006 SI	465	853/04	Sudeley 102/04	R	AC	ac
2006 SI	466	853/04	Sudeley 102/04	E	AC	ac
2006 SI	477	743/04	Sudeley 102/04	R	AB	ab
2006 SI	516	532/04	Sudeley 102/04	R	AC	ac
2006 SI	539	799/04	Sudeley 102/04	E	BC	ac
2006 SI	726	615/04	Sudeley 102/04	R	AB	ab
2006 SI	727	615/04	Sudeley 102/04	E	AC	bc
2006 SI	892	361/04	Sudeley 102/04	E	BC	ab
2006 SI	896	345/04	Sudeley 102/04	E	BC	ac
2006 SI	909	793/04	Sudeley 102/04	R	BC	ac
2006 SI	910	793/04	Sudeley 102/04	E	BC	ac
2006 SI	1015	848/04	Sudeley 102/04	R	AC	bc
2006 SI	1053	624/04	Sudeley 102/04	R	BC	ac
2006 SI	1284	851/04	Sudeley 102/04	R	CC	
2006 SI	141	268/04	Offord 414/01	E	BC	ac
2006 SI	247	493/04	Offord 414/01	R	BC	ac
2006 SI	293	223/04	Offord 414/01	E	BC	ab

2006 SI	352	670/04	Offord 414/01	R	BC	ac
2006 SI	406	559/04	Offord 414/01	E	BC	ab
2006 SI	554	775/04	Offord 414/01	R	BC	ac
2006 SI	868	746/04	Offord 414/01	E	BC	ac
2006 SI	905	740/04	Offord 414/01	R	BC	ac
2006 SI	957	294/04	Offord 414/01	R	BC	bc
2006 SI	976	508/04	Offord 414/01	R	BC	bc
2006 SI	1070	388/04	Offord 414/01	R	BC	ac
2006 SI	87	783/04	Mana 90/01	R	AC	ac
2006 SI	181	456/04	Mana 90/01	E	BC	ac
2006 SI	217	57/04	Mana 90/01	R	BC	ac
2006 SI	267	158/04	Mana 90/01	R	BC	ac
2006 SI	283	702/04	Mana 90/01	E	BC	ac
2006 SI	288	279/04	Mana 90/01	R	BC	ac
2006 SI	338	768/04	Mana 90/01	E	BC	ac
2006 SI	339	768/04	Mana 90/01	E	BC	ac
2006 SI	422	64/04	Mana 90/01	R	BC	ac
2006 SI	427	594/04	Mana 90/01	R	BC	ac
2006 SI	441	476/04	Mana 90/01	R	BC	ac
2006 SI	705	374/04	Mana 90/01	R	BC	ac
2006 SI	706	374/04	Mana 90/01	E	AC	ac
2006 SI	730	381/04	Mana 90/01	R	AC	ac
2006 SI	731	381/04	Mana 90/01	E	AC	ac
2006 SI	756	590/04	Mana 90/01	R	BC	ac
2006 SI	773	585/04	Mana 90/01	R	BC	ac
2006 SI	774	585/04	Mana 90/01	E	BC	ac
2006 SI	1017	672/04	Mana 90/01	E	BC	ac
2006 SI	1027	144/04	Mana 90/01	R	BC	ac
2006 SI	1032	71/04	Mana 90/01	E	AC	ac
2006 SI	1051	465/04	Mana 90/01	R	BC	ac
2006 SI	1072	295/04	Mana 90/01	R	AC	ac
2006 SI	1086	449/04	Mana 90/01	R	BC	ac
2006 SI	1107	819/04	Mana 90/01	R	BC	ac
2006 SI	1289	650/04	Mana 90/01	E	AC	ac
2006 SI	19	93/04	Mana 83/04	E	AC	ac
2006 SI	24	728/04	Mana 83/04	R	BC	ac
2006 SI	64	685/04	Mana 83/04	R	BC	ac
2006 SI	65	520/04	Mana 83/04	E	BC	ac
2006 SI	103	429/04	Mana 83/04	R	BC	ac
2006 SI	148	669/04	Mana 83/04	R	BC	ac
2006 SI	350	722/04	Mana 83/04	R	BC	ac
2006 SI	359	183/04	Mana 83/04	E	BC	bc
2006 SI	398	468/04	Mana 83/04	E	BC	ac
2006 SI	409	455/04	Mana 83/04	R	BC	ac
2006 SI	418	218/04	Mana 83/04	E	BC	ac

2006 SI	446	370/04	Mana 83/04	R	BC	ac
2006 SI	529	651/04	Mana 83/04	E	BC	ac
2006 SI	530	712/04	Mana 83/04	R	BC	ac
2006 SI	531	712/04	Mana 83/04	E	BC	ac
2006 SI	568	15 /04	Mana 83/04	E	BC	ac
2006 SI	587	142/04	Mana 83/04	E	BC	ac
2006 SI	601	573/04	Mana 83/04	E	BC	ac
2006 SI	673	786/04	Mana 83/04	E	BC	ac
2006 SI	712	248/04	Mana 83/04	E	BC	ac
2006 SI	713	145/04	Mana 83/04	R	BC	ac
2006 SI	728	832/04	Mana 83/04	R	AC	bc
2006 SI	753	304/04	Mana 83/04	E	AC	bc
2006 SI	783	535/04	Mana 83/04	R	BC	ac
2006 SI	784	535/04	Mana 83/04	E	BC	ac
2006 SI	802	173/04	Mana 83/04	R	BC	ac
2006 SI	865	562/04	Mana 83/04	E	BC	ac
2006 SI	879	688/04	Mana 83/04	R	BC	ac
2006 SI	880	688/04	Mana 83/04	E	BC	ac
2006 SI	914	795/04	Mana 83/04	R	BC	ac
2006 SI	1096	735/04	Mana 83/04	R	BC	ab
2006 SI	1185	498/04	Mana 83/04	R	BC	ac
2006 SI	1186	498/04	Mana 83/04	R	BC	ac
2006 SI	1238	524/04	Mana 83/04	R	AC	bc
2006 SI	3130	215/04	Mana 83/04	E	BC	ac
2006 SI	3152	844/04	Mana 83/04	R	AC	
2006 SI	85	518/04	Longridge 626/02	E	AB	ab
2006 SI	159	825/04	Longridge 626/02	R	AB	ab
2006 SI	160	825/04	Longridge 626/02	R	AB	ab
2006 SI	191	706/04	Longridge 626/02	R	AC	ab
2006 SI	192	706/04	Longridge 626/02	R	AB	ab
2006 SI	209	464/04	Longridge 626/02	R	AC	ab
2006 SI	237	675/04	Longridge 626/02	R	AB	ab
2006 SI	238	675/04	Longridge 626/02	E	AB	ab
2006 SI	326	764/04	Longridge 626/02	R	AB	ab
2006 SI	829	625/04	Longridge 626/02	E	AB	ab
2006 SI	1047	621/04	Longridge 626/02	R	AB	ab
2006 SI	1098	301/04	Longridge 626/02	R	AB	ab
2006 SI	1137	794/04	Longridge 626/02	R	AB	ab
2006 SI	1277	369/04	Longridge 626/02	E	AC	ab
2006 SI	3140	56/04	Longridge 626/02	R	AC	ab
2006 SI	302	797/04	Hermiston 22/04	R	BC	ac
2006 SI	312	197/04	Hermiston 22/04	E	BC	ac
2006 SI	467	509/04	Hermiston 22/04	E	BC	ac
2006 SI	534	673/04	Hermiston 22/04	R	BC	ac
2006 SI	535	673/04	Hermiston 22/04	E	BC	ac

2006 SI	613	841/04	Hermiston 22/04	R	BC	ac
2006 SI	767	683/04	Hermiston 22/04	R	AC	
2006 SI	907	368/04	Hermiston 22/04	R	AC	ac
2006 SI	920	161/04	Hermiston 22/04	R	BC	ac
2006 SI	967	420/04	Hermiston 22/04	R	AC	ac
2006 SI	968	420/04	Hermiston 22/04	R	BC	ac
2006 SI	973	829/04	Hermiston 22/04	R	BC	ac
2006 SI	1106	313/04	Hermiston 22/04	R	BC	ac
2006 SI	1124	761/04	Hermiston 22/04	E	BC	ac
2006 SI	1205	16 /04	Hermiston 22/04	E	BC	ac
2006 SI	3131	85/04	Hermiston 22/04	E	BC	ac
2006 SI	3137	190/04	Hermiston 22/04	R	BC	ac
2006 SI	90	61/04	Glenleith 252/04	E	AB	ab
2006 SI	127	156/04	Glenleith 252/04	E	AB	ab
2006 SI	151	310/04	Glenleith 252/04	R	AB	ab
2006 SI	189	288/04	Glenleith 252/04	E	AB	ab
2006 SI	407	459/04	Glenleith 252/04	E	AC	bc
2006 SI	511	383/04	Glenleith 252/04	R	AC	ab
2006 SI	512	383/04	Glenleith 252/04	E	AC	bc
2006 SI	524	823/04	Glenleith 252/04	E	AB	ab
2006 SI	525	823/04	Glenleith 252/04	E	AB	ab
2006 SI	563	607/04	Glenleith 252/04	R	AB	ab
2006 SI	564	607/04	Glenleith 252/04	R	AB	ab
2006 SI	615	836/04	Glenleith 252/04	R	AC	ab
2006 SI	616	836/04	Glenleith 252/04	R	AC	ab
2006 SI	657	438/04	Glenleith 252/04	E	AB	ab
2006 SI	709	511/04	Glenleith 252/04	E	AC	bc
2006 SI	777	442/04	Glenleith 252/04	R	AC	bc
2006 SI	823	620/04	Glenleith 252/04	E	AB	ab
2006 SI	863	333/04	Glenleith 252/04	R	AC	ab
2006 SI	1042	638/04	Glenleith 252/04	R	AB	ab
2006 SI	1153	721/04	Glenleith 252/04	E	AB	ab
2006 SI	28	474/04	Glenleith 25/02	R	AC	bc
2006 SI	29	474/04	Glenleith 25/02	E	AB	ac
2006 SI	33	622/04	Glenleith 25/02	R	BC	ab
2006 SI	61	637/04	Glenleith 25/02	R	BC	ac
2006 SI	123	384/04	Glenleith 25/02	E	AC	bc
2006 SI	268	766/04	Glenleith 25/02	R	AB	ab
2006 SI	269	766/04	Glenleith 25/02	R	BC	ac
2006 SI	273	220/04	Glenleith 25/02	E	AB	ab
2006 SI	306	415/04	Glenleith 25/02	R	BC	ac
2006 SI	365	95/04	Glenleith 25/02	R	BC	ac
2006 SI	384	501/04	Glenleith 25/02	E	BC	ac
2006 SI	449	461/04	Glenleith 25/02	R	AB	ab
2006 SI	450	461/04	Glenleith 25/02	E	BC	ac

2006 SI	540	462/04	Glenleith 25/02	R	BC	ac
2006 SI	541	462/04	Glenleith 25/02	E	AC	bc
2006 SI	604	660/04	Glenleith 25/02	E	BC	ac
2006 SI	734	626/04	Glenleith 25/02	R	BC	ac
2006 SI	735	626/04	Glenleith 25/02	R	BC	ac
2006 SI	843	659/04	Glenleith 25/02	R	AC	ac
2006 SI	844	659/04	Glenleith 25/02	E	AC	ac
2006 SI	871	356/04	Glenleith 25/02	R	BC	ac
2006 SI	937	174/04	Glenleith 25/02	R	AC	bc
2006 SI	954	305/04	Glenleith 25/02	E	BC	ab
2006 SI	1010	596/04	Glenleith 25/02	R	AC	bc
2006 SI	1144	424/04	Glenleith 25/02	R	AC	ac
2006 SI	1173	816/04	Glenleith 25/02	E	AC	ac
2006 SI	1200	332/04	Glenleith 25/02	R	AB	ab
2006 SI	1240	682/04	Glenleith 25/02	R	BC	ac
2006 SI	1268	426/04	Glenleith 25/02	E	BC	ac
2006 SI	3146	49/04	Glenleith 25/02	R	AC	bc
2006 SI	1178	418/04	Doughboy 45/04	R	BC	ab
2006 SI	6	346/04	Braebank 67/03	R	AC	ab
2006 SI	258	328/04	Braebank 67/03	E	AC	ac
2006 SI	262	552/04	Braebank 67/03	E	AC	ac
2006 SI	330	385/04	Braebank 67/03	E	AC	ac
2006 SI	331	385/04	Braebank 67/03	E	AC	ac
2006 SI	332	684/04	Braebank 67/03	E	AC	ac
2006 SI	348	411/04	Braebank 67/03	E	AC	ac
2006 SI	367	162/04	Braebank 67/03	E	AC	ab
2006 SI	544	431/04	Braebank 67/03	E	AC	ac
2006 SI	635	506/04	Braebank 67/03	E	AC	ac
2006 SI	636	618/04	Braebank 67/03	R	AC	ac
2006 SI	719	90/04	Braebank 67/03	E	AC	ac
2006 SI	881	770/04	Braebank 67/03	E	AC	ab
2006 SI	882	770/04	Braebank 67/03	E	AC	ab
2006 SI	1248	454/04	Braebank 67/03	R	AC	ab
2006 SI	58	366/04	Banklea 217/00	E	AC	bc
2006 SI	130	116/04	Banklea 217/00	R	AB	ab
2006 SI	162	772/04	Banklea 217/00	E	AC	ab
2006 SI	292	202/04	Banklea 217/00	R	BC	ab
2006 SI	301	335/04	Banklea 217/00	R	AC	ac
2006 SI	470	773/04	Banklea 217/00	E	BC	ab
2006 SI	646	782/04	Banklea 217/00	R	BC	ab
2006 SI	647	782/04	Banklea 217/00	E	AC	ac
2006 SI	686	680/04	Banklea 217/00	R	BC	ac
2006 SI	687	680/04	Banklea 217/00	R	AC	bc
2006 SI	692	774/04	Banklea 217/00	E	BC	ab
2006 SI	793	657/04	Banklea 217/00	R	AC	ab

2006 SI	856	475/04	Banklea 217/00	R	AB	ab
2006 SI	931	237/04	Banklea 217/00	E	BC	ab
2006 SI	979	852/04	Banklea 217/00	R	AB	ab
2006 SI	1009	767/04	Banklea 217/00	E	AB	ab
2006 SI	1063	749/04	Banklea 217/00	E	AB	ab
2006 SI	1064	353/04	Banklea 217/00	R	AC	bc
2006 SI	1065	353/04	Banklea 217/00	R	BC	ac
2006 SI	1109	350/04	Banklea 217/00	E	AC	ab
2006 SI	1216	186/04	Banklea 217/00	R	AC	bc
2006 SI	1287	771/04	Banklea 217/00	R	BC	ac
2006 SI	1288	771/04	Banklea 217/00	E	AC	bc
2006 SI	3132	228/04	Banklea 217/00	E	AB	ab
2006 SI	3136	32/04	Banklea 217/00	E	AC	ac
2006 SI	3154	697/04	Banklea 217/00	E	AC	ac
2006 SI	3189	298/04	Banklea 217/00	R	AC	bc
2006 SI	1136			E	AB	ab
2006 SI	1222				AB	ab
2006 SI	1293				BC	ab

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Table A. 1 This is a sample caption for a table appearing in appendix A

To add the tables from your appendices to your List of Tables, go to the bottom of your List of Tables and press Enter a couple of times to give you a blank line between. Then go to the References ribbon | click on 'Insert Table of Figures' | select the caption label 'Table A.' (for tables in appendix A) | click Ok. If it asks you 'do you want to replace the current list', answer 'No', and a list of tables (that occur in Appendix A) will appear. Press Enter for a blank line, and create another list for tables that appear in appendix B, etc. I suggest you leave the blank line between each list. Do the same for figures.

Appendix B

PRKAG3 Gene

B.1 Allele Frequencies

Appendix B.1. 1; Allele Frequencies of PRKAG3

PRKAG3	**A**	**B**
	72%	28%

B.2 Tukey Pairwise Comparisons

Appendix B.2. 1; PRKAG3 vs. Breed

breed	N	Mean	Grouping
Borderdale	10	2.700	A
South Down	6	2.667	A B
Perendale	7	2.286	A B C
Dohne	5	2.200	A B C
Suffolk	10	1.800	A B C
South Suffolk	9	1.778	A B C
Charollais	12	1.750	A B C
White Dorper	15	1.667	A B C
Merino	10	1.400	B C
Poll Dorset	19	1.263	C
Coopworth	20	1.250	C
Texel	15	1.200	C
Border Leicester	10	1.200	C
Romney	12	1.167	C
Suffollk	7	1.143	C
Corriedale	8	1.125	C
Dorset Down	4	1.000	B C

Means that do not share a letter are significantly different.

Appendix B.2. 2; P values for of PRKAG3 vs. Breed

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
breed					
Border Leicester	-0.632	0.341	-1.85	0.066	5.24
Borderdale	0.868	0.341	2.55	0.012	5.24
Charollais	0.218	0.237	0.92	0.358	2.75
Coopworth	-0.432	0.196	-2.20	0.029	2.43
Corriedale	-0.742	0.332	-2.23	0.027	4.55
Dohne	0.368	0.406	0.91	0.365	5.82
Dorset Down	-0.532	0.371	-1.43	0.153	4.57
Merino	0.077	0.319	0.24	0.809	4.59
Perendale	0.986	0.367	2.69	0.008	5.29
Poll Dorset	-0.389	0.204	-1.90	0.059	2.57
Romney	-0.210	0.267	-0.79	0.433	3.50
South Down	0.835	0.386	2.17	0.032	5.54
South Suffolk	0.204	0.262	0.78	0.437	2.96
Suffolk	0.268	0.254	1.06	0.292	2.90
Suffollk	-0.772	0.364	-2.12	0.035	5.19
Texel	-0.408	0.217	-1.88	0.061	2.55

Appendix B.2. 3; PRKAG3 vs. Breed Purpose

Purpose	N	Mean	Grouping
Dual	72	1.583	A
Meat	97	1.5464	A
Wool	10	1.400	A

Means that do not share a letter are significantly different.

B.3 PRKAG3 Raw Data

Sample Number	Breed	Purpose	Genotype
1	Border Leicester	Dual	aa
2	Border Leicester	Dual	aa
3	Border Leicester	Dual	aa
4	Border Leicester	Dual	aa
5	Border Leicester	Dual	aa
6	Border Leicester	Dual	aa
7	Border Leicester	Dual	aa
8	Border Leicester	Dual	aa
9	Border Leicester	Dual	aa
10	Border Leicester	Dual	bb
11	Borderdale	Dual	aa
12	Borderdale	Dual	ab
13	Borderdale	Dual	bb
14	Borderdale	Dual	bb
15	Borderdale	Dual	bb
16	Borderdale	Dual	bb

17	Borderdale	Dual	bb
18	Borderdale	Dual	bb
19	Borderdale	Dual	bb
20	Borderdale	Dual	bb
21	Charollais	Meat	aa
22	Charollais	Meat	aa
23	Charollais	Meat	aa
24	Charollais	Meat	aa
25	Charollais	Meat	aa
26	Charollais	Meat	aa
27	Charollais	Meat	aa
28	Charollais	Meat	ab
29	Charollais	Meat	bb
30	Charollais	Meat	bb
31	Charollais	Meat	bb
32	Charollais	Meat	bb
33	Coopworth	Dual	aa
34	Coopworth	Dual	aa
35	Coopworth	Dual	aa
36	Coopworth	Dual	aa
37	Coopworth	Dual	aa
38	Coopworth	Dual	aa
39	Coopworth	Dual	aa
40	Coopworth	Dual	aa
41	Coopworth	Dual	bb
42	Coopworth	Dual	bb
43	Coopworth	Dual	aa
44	Coopworth	Dual	aa
45	Coopworth	Dual	aa
46	Coopworth	Dual	aa
47	Coopworth	Dual	aa
48	Coopworth	Dual	aa
49	Coopworth	Dual	aa
50	Coopworth	Dual	aa
51	Coopworth	Dual	aa
52	Coopworth	Dual	ab
53	Corriedale	Dual	aa
54	Corriedale	Dual	aa
55	Corriedale	Dual	aa
56	Corriedale	Dual	aa
57	Corriedale	Dual	aa
58	Corriedale	Dual	aa
59	Corriedale	Dual	aa
60	Corriedale	Dual	ab
61	Dohne	Dual	aa

62	Dohne	Dual	aa
63	Dohne	Dual	bb
64	Dohne	Dual	bb
65	Dohne	Dual	bb
66	Dorset Down	Meat	aa
67	Dorset Down	Meat	aa
68	Dorset Down	Meat	aa
69	Dorset Down	Meat	aa
70	Merino	Wool	aa
71	Merino	Wool	aa
72	Merino	Wool	aa
73	Merino	Wool	aa
74	Merino	Wool	aa
75	Merino	Wool	aa
76	Merino	Wool	ab
77	Merino	Wool	ab
78	Merino	Wool	bb
79	Merino	Wool	aa
80	Perendale	Dual	aa
81	Perendale	Dual	aa
82	Perendale	Dual	ab
83	Perendale	Dual	bb
84	Perendale	Dual	bb
85	Perendale	Dual	bb
86	Perendale	Dual	bb
87	Poll Dorset	Meat	aa
88	Poll Dorset	Meat	aa
89	Poll Dorset	Meat	aa
90	Poll Dorset	Meat	ab
91	Poll Dorset	Meat	bb
92	Poll Dorset	Meat	bb
93	Poll Dorset	Meat	aa
94	Poll Dorset	Meat	aa
95	Poll Dorset	Meat	aa
96	Poll Dorset	Meat	aa
97	Poll Dorset	Meat	aa
98	Poll Dorset	Meat	aa
99	Poll Dorset	Meat	aa
100	Poll Dorset	Meat	aa
101	Poll Dorset	Meat	aa
102	Poll Dorset	Meat	aa
103	Poll Dorset	Meat	aa
104	Poll Dorset	Meat	aa
105	Poll Dorset	Meat	aa
106	Romney	Dual	aa

107	Romney	Dual	aa
108	Romney	Dual	aa
109	Romney	Dual	aa
110	Romney	Dual	aa
111	Romney	Dual	aa
112	Romney	Dual	ab
113	Romney	Dual	ab
114	Romney	Dual	aa
115	Romney	Dual	aa
116	Romney	Dual	aa
117	Romney	Dual	aa
118	South Down	Meat	aa
119	South Down	Meat	bb
120	South Down	Meat	bb
121	South Down	Meat	bb
122	South Down	Meat	bb
123	South Down	Meat	bb
124	South Suffolk	Meat	bb
125	South Suffolk	Meat	aa
126	South Suffolk	Meat	aa
127	South Suffolk	Meat	aa
128	South Suffolk	Meat	aa
129	South Suffolk	Meat	aa
130	South Suffolk	Meat	ab
131	South Suffolk	Meat	bb
132	South Suffolk	Meat	bb
133	Suffolk	Meat	aa
134	Suffolk	Meat	aa
135	Suffolk	Meat	aa
136	Suffolk	Meat	aa
137	Suffolk	Meat	aa
138	Suffolk	Meat	aa
139	Suffolk	Meat	bb
140	Suffolk	Meat	bb
141	Suffolk	Meat	bb
142	Suffolk	Meat	bb
143	Suffollk	Meat	aa
144	Suffollk	Meat	aa
145	Suffollk	Meat	aa
146	Suffollk	Meat	aa
147	Suffollk	Meat	aa
148	Suffollk	Meat	aa
149	Suffollk	Meat	ab
150	Texel	Meat	aa
151	Texel	Meat	aa

152	Texel	Meat	aa
153	Texel	Meat	aa
154	Texel	Meat	aa
155	Texel	Meat	aa
156	Texel	Meat	aa
157	Texel	Meat	aa
158	Texel	Meat	aa
159	Texel	Meat	aa
160	Texel	Meat	aa
161	Texel	Meat	aa
162	Texel	Meat	aa
163	Texel	Meat	ab
164	Texel	Meat	bb
165	White Dorper	Meat	aa
166	White Dorper	Meat	aa
167	White Dorper	Meat	aa
168	White Dorper	Meat	aa
169	White Dorper	Meat	aa
170	White Dorper	Meat	aa
171	White Dorper	Meat	aa
172	White Dorper	Meat	aa
173	White Dorper	Meat	bb
174	White Dorper	Meat	bb
175	White Dorper	Meat	aa
176	White Dorper	Meat	aa
177	White Dorper	Meat	bb
178	White Dorper	Meat	bb
179	White Dorper	Meat	bb

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